ÖZGEÇMİŞ

1980 Ankara doğumlu olan Dr. Biçeroğlu ilk öğrenimini Kocaeli Gebze Darıca İlköğretim Okulunda, Orta öğrenimini Fevziye Mektepleri Vakfı Nişantaşı Işık Lisesi'nde, Lise eğitimini ise Üsküdar Fen Lisesi'nde tamamlamıştır. 1998-2004 tarihleri arasında Hacettepe Üniversitesi Tıp Fakültesini bitirmiş ve 2005 yılında İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi Beyin ve Sinir Cerrahisi Anabilim Dalında ihtisasa başlamıştır. Haziran 2010-Haziran 2011 tarihleri arasında Yüksek Öğretim Kurumu (YÖK) Doktora Araştırma Bursu almaya hak kazanarak ve İstanbul Üniversitesi Rektörlüğü tarafından görevlendirilerek ABD'de "University of Florida McKnight Brain Institute Department of Neurosurgery"de Prof. Dr. Albert Rhoton Jr.'ın yanında "Microsurgical Neuroanatomy Fellow"u olarak Ak Madde ve Nukleus Diseksiyonları, Davranışsal ve Kognitif Nöroşirurji'nin Cerrahi Anatomisi üzerine çalışmıştır ve Şubat 2012 tarihinde Cerrahpaşa Tıp Fakültesi Beyin ve Sinir Cerrahisi Anabilim Dalındaki ihtisasını tamamlayarak Beyin ve Sinir Cerrahisi Uzmanı olmuştur. Evli 18 yaşında ve 12 yaşında iki erkek çocuk babası olan Dr. Biçeroğlu Mayıs 2012-Kasım 2013 tarihleri arasında T.C. Sağlık Bakanlığı Kırşehir Ahi Evran Üniversitesi Eğitim ve Araştırma Hastanesi'nde mecburi hizmetini yapmıştır. Şubat 2014- Nisan 2020 tarihleri arasında Ege Üniversitesi Tıp Fakültesi Beyin ve Sinir Cerrahisi Anabilim Dalı'nda Uzman Doktor olarak çalışmıştır. Ege Üniversitesinde geçirdiği bu sürenin 4.5 yılında ayda 15 gece ameliyat yapmış veya yaptırmış , nöbet ertesi gün de ameliyat yapmaya ve yaptırmaya devam ederek yoğun bir dönem geçirmiştir. Bilimsel geçmişinde **17 Kitap , 14 Kitap Bölümü , 54 Ulusal-Uluslararası Makale, 158 Ulusal-Uluslararası Bildiri ve Poster , 397 Atıf** yer almaktadır . Halen **16 Bilimsel Projede** Yürütücü veya Araştırmacı olarak görev almaktadır. Ulusal-Uluslararası Bilimsel Kongre,Toplantı ve Kurslarda **125 farklı faaliyet için "Davetli Konuşma" , "Oturum Başkanlığı" veya "Kurs Eğitmenliği"** daveti almış ve gerçekleştirmiştir. Halen Ege Üniversitesi Tıp Fakültesi Beyin ve Sinir Cerrahisi Anabilim Dalı'nda Doçent Doktor olarak çalışmaktadır.

Web of Science Researcher ID : **JXW-6513-2024** (**h-index 11**)
Scopus ID: **24464838100** (313 Citations, **h-index 11**)
Google Scholar : (397 Citations **h-index 12** , **i10- index 14**)
ORCID ID: **https://orcid.org/0000-0003-2306-0826**

EĞİTİM BİLGİLERİ

2005 - 2012

Tıpta Uzmanlık, İstanbul Üniversitesi-Cerrahpaşa, Cerrahpaşa Tıp Fakültesi, Beyin Ve Sinir Cerrahisi Anabilim Dalı, Türkiye

2010 - 2011

Post Doktora, University of Florida, Mc Knight Brain Institute , Department Of Neurosurgery , Amerika Birleşik Devletleri

1998 - 2004 Yüksek Lisans, Hacettepe Üniversitesi, Tıp Fakültesi, Türkiye

Yabancı Diller

Almanca, B1 Orta İngilizce, C1 İleri

TÜBİTAK BURS VE DESTEKLERİ

1. Proje Bilgileri 324S268, **3 Boyutlu Yazıcı Yardımlı Spinal Faset Blokajı Eğitim Modeli**, **YÜRÜTÜCÜ**, Yürürlükte, SBAG - Sağlik Bilimleri Araştirma Destek Grubu, 1002 - Hızlı Destek / Hızlı Destek - A, ARDEB, Projeye Katılma/Ayrılma Tarihleri: 27.12.2024 - (), Proje Başlangıç/Bitiş Tarihleri: 27.12.2024 - 27.12.2025.

2. Proje Bilgileri 220S214, **Nikotin Bağımlılığı Tedavisi için Elektromanyetik Vagus Sinir Uyarıcısı Geliştirilmesi**, **ARAŞTIRMACI/UZMAN**, Sonuçlandı, SBAG - Sağlik Bilimleri Araştirma Destek Grubu, 1001 - Araştırma, ARDEB, Projeye Katılma/Ayrılma Tarihleri: 15.03.2021 - (), Proje Başlangıç/Bitiş Tarihleri: 15.03.2021 - 15.03.2024.

BURSLAR

2010 - 2011 YÖK DOKTORA ARAŞTIRMA BURSU, YÖK

YAPTIĞI TEZLER

Lateral ve Bazal Temporal Lobun Sulkal Varyasyonları:Cerrahi Anatomi ve MRG Sonuçlarının Mezial Temporal Bölgeye Yaklaşım için Değerlendirilmesi, İstanbul Üniversitesi-Cerrahpaşa, Cerrahpaşa Tıp Fakültesi, Beyin Ve Sinir Cerrahisi Anabilim Dalı, Tıpta Uzmanlık

YÜRÜTÜCÜ/ARAŞTIRMACI OLDUĞU BİLİMSEL PROJELER

1. **Investigation of the Effects of a Next-Generation Nerve Guidance Conduit Based on Natural Polymers Loaded with Vascular Endothelial Growth Factor (VEGF) and Nerve Growth Factor (NGF) on Regeneration and Vascularization in Peripheral Nerve Injuries**

   ARAŞTIRMACI

2. **Outsmarting the Troublemaker: A Subpectoral Protocol for Implantable Pulse Generators**

   Proje yürütücüsü Doç. Dr. Hüseyin BİÇEROĞLU

3. **Risk Factors for Sinking Skin Flap Syndrome After Decompressive Craniectomy in Aneurysmal Subarachnoid Hemorrhage**

   Proje yürütücüsü Doç. Dr. Hüseyin BİÇEROĞLU

4. Proje no 33324
   Proje adı **Astacus astacus Modelinde Uzay Ortamı Koşullarının Sinirsel Adaptasyon ve Rejenerasyon Üzerine Etkilerinin İmplante Edilebilir Nöromonitör ile İncelenmesi**
   Proje türü Araştırma Üniversiteleri Destek Programı, Proje grubu: Fen ve Mühendislik Proje süresi (ay) 36 ay
   Proje yürütücüsü Dr. Öğr. Üyesi Barış Oğuz GÜRSES

   Doç.Dr.Hüseyin Biçeroğlu ARAŞTIRMACI

5. Proje no 33308 Takip no TS-TUT-2025-33308
   Proje adı **Perkütan Gasser Ganglion Rizotomi için Üç Boyutlu Yazıcı Destekli Eğitim Modeli Geliştirilmesi** Proje türü Tez Projesi, Tıpta Uzmanlık Proje grubu Tıp Sağlık Proje süresi (ay) 12 ay Proje durumu Yürüyen proje
   Proje yürütücüsü Prof. Dr. Taşkın YURTSEVEN

   Doç.Dr.Hüseyin Biçeroğlu ARAŞTIRMACI

6. Proje no 33270
   Proje adı **Nikotin Bağımlılığı Tedavisi için Transkraniyal Manyetik Uyarım Cihazı Geliştirilmesi ve Etkinliğinin Araştırılması**
   Proje türü Çok Disiplinli Öncelikli Alan Araştırma Projesi
   Proje grubu Fen ve Mühendislik Proje süresi (ay) 36 ay
   Proje yürütücüsü Dr. Öğr. Üyesi Barış Oğuz GÜRSES

   Doç.Dr.Hüseyin Biçeroğlu ARAŞTIRMACI

7. Proje no 33262 Takip no TS-GAP-2025-33262
   Proje adı **Robotik Destekli Çerçevesiz Derin Beyin Stimülatörü (DBS) Takılmasının Kadavra Üzerinde Doğruluk Analizi**
   Proje türü Genel Araştırma Projesi Proje grubu Tıp Sağlık Proje süresi (ay) 18 ay
   Proje durumu Yürüyen proje

   Proje yürütücüsü Doç. Dr. Hüseyin BİÇEROĞLU

8. Proje no 31851 Takip no TS-GAP-2023-31851
   Proje adı **Periferik Sinir Hasarında Olfaktör Mukozal Mezenkimal Kök Hücrelerinin Terapötik Etkinliğinin İncelenmesi**
   Proje türü Genel Araştırma Projesi Proje grubu Tıp Sağlık Proje süresi (ay) 24 ay
   Yöksis gönderim tarihi Perşembe, 3 Temmuz 2025 16:34 Proje durumu Kapanmış (Yayın bekleniyor)
   Proje yürütücüsü
   Prof. Dr. Yiğit UYANIKGİL

   Doç.Dr.Hüseyin Biçeroğlu ARAŞTIRMACI

9. Proje no 29676 Takip no TS-TUT-2023-29676
Proje adı **BOSoMetre:Sürekli Beyin Omurilik Monitörizasyonu Sistemi**
Proje türü Tez Projesi, Tıpta Uzmanlık Proje grubu Tıp Sağlık Proje süresi (ay) 24 ay
Yöksis gönderim tarihi Perşembe, 20 Mart 2025 16:16
Proje durumu Kapanmış

Proje yürütücüsü Doç. Dr. Hüseyin BİÇEROĞLU

10. Proje no 28467 Takip no TS-GDM-2023-28467
Proje adı **Optik Tabanlı Magnetik Rezonans Bazlı Kızılötesi Kamera kullanımlı Nöronavigasyon ile Entegre edilmiş Cerrahi Mikroskop Temelli Arttırılmış Gerçeklik Uygulamalı Nöroonkolojik Robotik Cerrahi**
Proje türü Güdümlü Proje Proje alt türü Üniversite Güdümlü Proje Proje grubu Tıp Sağlık Proje süresi (ay) 24 ay Perşembe, 9 Ekim 2025 15:11
Proje durumu Kapanmış (Yayın bekleniyor)

Proje yürütücüsü Doç. Dr. Hüseyin BİÇEROĞLU

11. Proje no 23464 Takip no TSG-2022-23464
Proje adı **Burundan Kafa Kaidesi Hipofiz ve Beyin Tümörü Çıkarılması İleri Endoskopik Beyin Cerrahisi**
Proje türü Güdümlü Proje Proje alt türü Üniversite Güdümlü Proje Proje grubu Tıp Sağlık Proje süresi (ay) 24 ay Yöksis gönderim tarihi Perşembe, 25 Nisan 2024 16:35
Proje durumu Kapanmış (Yayın bekleniyor)

Proje yürütücüsü Doç. Dr. Hüseyin BİÇEROĞLU

12. Proje no 22041 Takip no TGA-2020-22041
Proje adı **Glioblastomada PTEN mutasyonlarının cGAS STING yolağına ve tedavi direncine etkilerinin araştırılması**
Proje türü Genel Araştırma Projesi Proje grubu Tıp Sağlık Proje süresi (ay) 24 ay
Yöksis gönderim tarihi Cuma, 1 Mart 2024 15:01 Proje durumu Kapanmış
Proje yürütücüsü
Doç. Dr. Vildan BOZOK ÇETİNTAŞ

Doç.Dr.Hüseyin Biçeroğlu ARAŞTIRMACI

13. Proje no 20642 Takip no TGA-2019-20642
Proje adı **Anevrizma Cerrahisinde Üç Boyutlu Yazıcı ile Preoperatif Modelleme ve Simülasyon**
Proje türü Genel Araştırma Projesi Proje grubu Tıp Sağlık Proje süresi (ay) 12 ay
Yöksis gönderim tarihi Pazartesi, 3 Nisan 2023 14:03 Proje durumu Kapanmış (Yayın bekleniyor)
Proje yürütücüsü Doç. Dr. Erkin ÖZGİRAY

Doç.Dr.Hüseyin Biçeroğlu ARAŞTIRMACI

14. Proje no 20329 Takip no TGA-2019-20329
Proje adı **Glioblastomada cGAS/STING yolağının tedavi direnci üzerine etkilerinin araştırılması**
Proje türü Genel Araştırma Projesi Proje grubu Tıp Sağlık Proje süresi (ay) 36 ay
Yöksis gönderim tarihi Pazartesi, 3 Nisan 2023 16:20 Proje durumu Kapanmış
Proje yürütücüsü Doç. Dr. Vildan BOZOK ÇETİNTAŞ

Doç.Dr.Hüseyin Biçeroğlu ARAŞTIRMACI

YAYINLANMIŞ KİTAPLAR

1. **Fonksiyonun Nöroşirurjikal Anatomisi 4 Cilt 2300 sayfa** . **Editör Biçeroğlu H.** , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. M. US Akademi, İzmir, 2019
2. **Nöroşirurji Yeterlik Sınavına Hazırlık 2 Cilt 100 Sayfa Editör Biçeroğlu H.**, Hancı M. M. Us Akademi, İzmir, 2016
3. **Baş Boyun ve Beyinin Nöroşürurjikal Anatomisi Biçeroğlu H**., Hancı M. M. US Akademi, İzmir, 2016
4. **Omurga'nın Cerrahi Anatomisi Biçeroğlu H.**, Hancı M. M. INTERTIP, Ankara, 2013
5. **Nöroşirürjide Aydınlatılmış Rıza Formları** Editörler: Prof.Dr. Hasan Serdar Işık, **Doç.Dr. Hüseyin Biçeroğlu,** Prof.Dr.Erdal Kalkan, Editör Yardımcıları : Prof.Dr.İlker Solmaz, Doç.Dr.Balkan Şahin, Doç.Dr.Ömer Özdemir. 2025 Türk Nöroşirurji Derneği Yayınları
6. **Kranial Rizopatiler** Editör **Biçeroğlu H.** , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. US Akademi, İzmir, 2020
7. **Psikoşirürji** Editör **Biçeroğlu H.** , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. US Akademi, İzmir, 2020
8. **Ağrı Cerrahisi** Editör **Biçeroğlu H.** , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. US Akademi, İzmir, 2020
9. **Hareket Bozuklukları Cerrahisi** Editör **Biçeroğlu H.** , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. US Akademi, İzmir, 2020
10. **Fonksiyon Değerlendirme ve Görüntüleme Teknikleri** Editör **Biçeroğlu H.** , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. US Akademi, İzmir, 2020
11. **Fonksiyonlara Özel Organizasyon** Editör **Biçeroğlu H**. , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. US Akademi, İzmir, 2020
12. **Bölgelere Göre Fonksiyonel Organizasyon** Editör **Biçeroğlu H.** , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. US Akademi, İzmir, 2020
13. **Kranial ve Periferik Sinirlerin Fonksiyonel ve Mikrocerrahi Anatomisi** Editör **Biçeroğlu H.** , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. US Akademi, İzmir, 2020
14. **Epilepsi Cerrahisi** Editör **Biçeroğlu H.** , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. US Akademi, İzmir, 2020
15. **Ak Madde ve Gri Maddenin Fonksiyonel Anatomisi** Editör **Biçeroğlu H.** , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. US Akademi, İzmir, 2020
16. **Başlıca Nörolojik Ve Psikiyatrik Hastalıklar Ve Medikal Tedavi Yöntemleri, Fonksiyonel Ve Kognitif Özellikleri** Editör **Biçeroğlu H.** , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. US Akademi, İzmir, 2020
17. **Spastisite Cerrahisi** Editör **Biçeroğlu H.** , Yardımcı Editörler: Tönge M., Seçkin M., Adıgüzel E., Gürvit H., Hancı M. US Akademi, İzmir, 2020

YAYINLANMIŞ KİTAP BÖLÜMLERİ

1. **Beyin Metastazlarında Cerrahi.** **Doç.Dr.Hüseyin Biçeroğlu** , Dr. Elif Ezgi Çenberlitaş. Beyin Metastazlarına Güncel Radyoterapi Yaklaşımı. Editör Prof.Dr. Serra Kamer e-ISBN 978-605-338-458-8
2. Beyin ve Sinir Cerrahisinde Acil Yaklaşımlar. Karagöz C., **Biçeroğlu H.** **Akut Bilinç Kaybının Değerlendirilmesi** . Nobel Yayın Dağıtım, Ankara, 2019
3. Fonksiyonun Nöroşirurjikal Anatomisi. Arslan D., **Biçeroğlu H.** **Klaustral Lifler.** Hüseyin Biçeroğlu,Mehmet Tönge,Mustafa Seçkin,Esat Adıgüzel,Hakan Gürvit,Murat Hancı, Editör, Us Akademii, İstanbul, ss.535-541, 2019
4. Endoskopik Sinüs Cerrahisi Atlası Karcı H. B. , **Biçeroğlu H.** **Sellar Parasellar Bölge Anatomisi**. Prof.Dr. Bülent Karcı , Prof.Dr. Raşit Midilli , Do.Dr. Sercan Göde, Editör, Nobel Tıp Kitabevi, İstanbul, ss.75-94, 2019
5. Fonksiyonun Nöroşirurjikal Anatomisi Arslan D., **Biçeroğlu H.** **Ekstrem Kapsül.** Hüseyin Biçeroğlu,Mehmet Tönge,Mustafa Seçkin,Esat Adıgüzel,Hakan Gürvit,Murat Hancı, Editör, US Akademi , İzmir, ss.481-485, 2019
6. Fonksiyonun Nöroşirurjikal Anatomisi Arslan D., **Biçeroğlu H.** **Eksternal Kapsül.** Hüseyin Biçeroğlu,Mehmet Tönge,Mustafa Seçkin,Esat Adıgüzel,Hakan Gürvit,Murat Hancı, Editör, Us Akademi, İzmir, ss.485-493, 2019
7. Nörolojik Bilimler Kitabı **Biçeroğlu H.**, Turhan T. **Hidrosefali Tedavisi**, Prof. Dr Emre Kumral, Editör, Ege Üniversitesi Yayınları Tıp Fakültesi Yayını, İzmir, 2019
8. Nöroşirurji Yeterlik Sınavına Hazırlık. Nasırov R., **Biçeroğlu H.** **Periferik Sinir Sistemi Cerrahisi** . Biçeroğlu H., Hancı M. M. Us Akademi, İzmir, 2016
9. US Akademi , İzmir, ss.453-460, 2016
10. Nöroşirurji Yeterlik Sınavına Hazırlık Davran H., **Biçeroğlu H.**, Girgin Biçeroğlu G. **Nöroanestezi.** Uzm.Dr.Hüseyin Biçeroğlu,Prof.Dr.Murat Hancı, Editör, US Akademi İzmir, ss.71-89, 2016
11. **Omurga'nın Cerrahi Anatomisi** . **Biçeroğlu H.** Omurga Ve Omurilik Yaralanmaları. Murat Hancı, Editör, intertıp, İstanbul, ss.11-36, 2013
12. Spastisite **Biçeroğlu H.** **Spastisitenin Anatomik Temelleri**, Prof.Dr. Murat Hancı, Doç.Dr. Belgin Erhan, Editör, Nobel Yayın Dağıtım, İstanbul, ss.53-60, 2011
13. Nöroşirurjiye Giriş **Biçeroğlu H.**, Ulu M. O. , Tanrıöver N., Çıplak N. **Supra ve İnfratentorial Bölge ve Ventriküller'in Mikrocerrahi Anatomisi** , Prof.Dr.Mustafa Uzan, Editör, Cerrahpaşa Tıp Fakültesi 40.Yıl Yayınları, İstanbul, ss.11-64, 2010
14. Nöroşirurjiye Giriş (Cerrahpaşa Tıp Fakültesi 40.Yıl Yayınları) **Biçeroğlu H.**, Ulu M. O. , Tanrıöver N., Çıplak N. **Nöroembriyoloji ve Nörofizyoloji'ye Giriş,** Prof.Dr. Mustafa Uzan, Editör, Cerrahpaşa Tıp Fakültesi 40.Yıl Yayınları, İstanbul, ss.1-10, 2010

YAYINLANMIŞ MAKALELER

1. Validation of a 3D-Printed Facet Injection Training Model with Real-Time Feedback: A Prospective Study on Neurosurgical Residents. Hüseyin Biçeroğlu, Bilal Bahadır Akbulut, Elif Ezgi Çenberlitaş, Barış Oğuz Gürses, Mustafa Serdar Bölük, Taşkın Yurtseven. Turkish Neurosurgery . Date Accepted: Dec 31, 2025 DOI: 10.5137/1019-5149.JTN.50284-25.3

   Aim:Pain injections are one of the most commonly done spinal procedures, yet there are no structured and safe platforms for teaching. We aimed to create a low-cost, 3D-printed lumbosacral model with real-time feedback for training residents in lumbar facet joint injections.Material and Methods:A 3D-printed lumbosacral model was created using barium-enhanced paint for fluoroscopic visibility and graphite-enhanced conductive paint for facet targets. A custom needle system connected to an Arduino-based circuit provided immediate visual and auditory feedback when the needle contacted correct or incorrect targets. Ten neurosurgery residents who had no prior experience with facet injections were involved. They all had three training sessions, which involved bilateral injections at L2-3, L3-4, and L4-5. Outcomes were procedure time, fluoroscopy shots, number of attempts, and complications.Results:There were significant improvements between sessions. The mean procedure time dropped to 27.5 ± 6.8 minutes in Session 2 and 16.7 ± 4.2 minutes in Session 3, which is a 61% decrease ($p < 0.001$).Median fluoroscopy use declined from 48 images (IQR: 42-54) in Session 1 to 32 (IQR: 28-38) in Session 2, and 22 (IQR: 18-26) in Session 3 ($p < 0.001$). Median number of attempts decreased from 16 (IQR: 13-19) in Session 1 to 12 (IQR: 10-14) in Session 2, and 8 (IQR: 6-10) in Session 3 ($p < 0.001$). There was no significant difference in complications, which is defined as contact with nerve root or spinal canal, among sessions ($p = 0.32$).Conclusion:This novel, feedback-enabled, 3D printed model is an effective platform for facet injection training that shows significant results in procedure time, fluoroscopy use, and attempts. In addition to facet injections, the system can then be adapted for other types of spinal procedures such as caudal, epidural, and transforaminal injections. As part of the SpineForge initiative, this open-source model supports the democratization of surgical education.

2. Comparative Outcomes of Keyhole and Burr hole Techniques in Surgical Management of Chronic Subdural Hematoma Akbulut, Bilal Bahadir; Bölük, Mustafa Serdar; Biçeroglu, Hüseyin; Yurtseven, Taskin Neurologico Spinale Medico Chirurgico 8(1):p 9-13, Jan–Apr 2025. | DOI: 10.4103/nsmc.nsmc_33_24

   Abstract

   Introduction: Chronic subdural hematoma (cSDH) is a common neurosurgical condition with various surgical approaches. We compared the outcomes of two standard techniques: keyhole craniotomy and burr hole drainage in a series managed by a single senior surgeon. Methods: This retrospective study reviewed cSDH surgeries at our institution between January 2013 and June 2023. Inclusion criteria were age ≥18 years, available pre- and postoperative imaging, 6-month follow-up, and closed drain placement. We analyzed demographic data, length of hospital stay, modified Rankin Scale (mRS) scores, American Society of Anesthesiologists (ASA) scores, radiological parameters, and recurrence rates.Results: Of 77 patients, 35 met inclusion criteria (14 burr hole and 21 keyhole). Both groups had similar baseline characteristics, including age, sex, preoperative mRS, ASA scores, and radiological parameters ($P > 0.05$). Recurrence occurred in three burr hole cases (mean 56 days) and two keyhole cases (mean 30 days) ($P = 0.207$). Surgical technique did not significantly affect postoperative mRS improvement ($P = 0.321$) or length of hospital stay ($P = 0.448$). Conclusion:

   Consistent with the current literature, this study has demonstrated that burr hole drainage for cSDH yields surgical outcomes similar to the keyhole technique. Considering its shorter operation time and more minimally invasive nature, burr hole drainage can be preferred for the evacuation of cSDHs.

3. Proof-of-concept study of noninvasive, rapid, machine learning–enhanced, color-based CSF diagnostics: a novel approach to external ventricular drain infection screening
   Akbulut, B.B., Gürses, B.O., Özgül, S., (...), Yurtseven, T., Biçeroğlu, H. 2026 Journal of Neurosurgery 144(1), pp. 228-238

OBJECTIVE The objective was to develop and validate a proof-of-concept, low-cost, noninvasive device capable of continuously monitoring CSF in external ventricular drainage systems in order to enable earlier detection of infections. METHODS The authors designed BOSoMetre (CSF-o-Meter), a device that uses a microcontroller and TCS3200 color sensor housed in a 3D-printed chamber for continuous CSF monitoring. The system captures real-time optical measurements across red, green, blue, and clear channels through the external ventricular drain (EVD) tube. Between October 2024 and January 2025, the authors prospectively enrolled 20 patients requiring EVD placement for obstructive hydrocephalus or infection, with 15 included in the final analysis. CSF samples were classified according to Infectious Diseases Society of America 2017 guidelines. The authors processed approximately 4.8 million sensor readings and applied machine learning algorithms using two validation approaches: the subspace k-nearest neighbors (KNN) classifier with 80-20 split validation, and random forest with leave-one-patient-out cross-validation (LOOCV). RESULTS The subspace KNN classifier with 80-20 split validation yielded 90.4% accuracy with 92% sensitivity and 90.4% specificity (area under the curve [AUC] 0.968). The more stringent random forest with LOOCV approach achieved 81.1% accuracy with 71.5% sensitivity and 89.2% specificity (AUC 0.736). The device successfully distinguished between clean and infected CSF samples, with particularly high specificity in identifying noninfected samples. CONCLUSIONS BOSoMetre shows promise as a low-cost (< €100), open-source tool for continuous CSF monitoring and early infection detection, especially for resource-limited settings. The high specificity could potentially reduce unnecessary CSF sampling and associated iatrogenic infection risks. Although the initial results are encouraging, further validation in larger cohorts is needed to confirm clinical utility and overcome the technical limitations identified in this proof-of-concept study.

4. From pixels to prognosis: leveraging radiomics and machine learning to predict IDH1 genotype in gliomas Karakas, A.B., Govsa, F., Ozer, M.A., (...), Eraslan, C., Tanir, D. 2025 Neurosurgical Review 48(1),396

Gliomas are the most common primary tumors of the central nervous system, and advances in genetics and molecular medicine have significantly transformed their classification and treatment. This study aims to predict the IDH1 genotype in gliomas using radiomics and machine learning (ML) methods. Retrospective data from 108 glioma patients were analyzed, including MRI data supported by demographic details such as age, sex, and comorbidities. Tumor segmentation was manually performed using 3D Slicer software, and 112 radiomic features were extracted with the PyRadiomics library. Feature selection using the mRMR algorithm identified 17 significant radiomic features. Various ML algorithms, including KNN, Ensemble, DT, LR, Discriminant and SVM, were applied to predict the IDH1 genotype. The KNN and Ensemble models achieved the highest sensitivity (92-100%) and specificity (100%), emerging as the most successful models. Comparative analyses demonstrated that KNN achieved an accuracy of 92.59%, sensitivity of 92.38%, specificity of 100%, precision of 100%, and an F1-score of 95.02%. Similarly, the Ensemble model achieved an accuracy of 90.74%, sensitivity of 90.65%, specificity of 100%, precision of 100%, and an F1-score of 95.13%. To evaluate their effectiveness, KNN and Ensemble models were compared with commonly used machine learning approaches in glioma classification. LR, a conventional statistical approach, exhibited lower predictive performance with an accuracy of 79.63%, while SVM, a frequently utilized ML model for radiomics-based tumor classification, achieved an accuracy of 85.19%. Our findings are consistent with previous research indicating that radiomics-based ML models achieve high accuracy in IDH1 mutation prediction, with reported performances typically exceeding 80%. These findings suggest that KNN and Ensemble models are more effective in capturing the non-linear radiomic patterns associated with IDH1 status, compared to traditional ML approaches. Our findings indicate that radiomic analyses provide comprehensive genotypic classification by assessing the entire tumor and present a safer, faster, and more patient-friendly alternative to traditional biopsies. This study highlights the potential of radiomics and ML techniques, particularly KNN, Ensemble, and SVM, as powerful tools for predicting the molecular characteristics of gliomas and developing personalized treatment strategies.

5. Periorbital sebaceous carcinoma with intracranial extension: A case report Çenberlitaş, E.E., Akbulut, B.B., Boluk, M.S., Yurtseven, T., Biçeroğlu, H. 2025 Journal of Experimental and Clinical Medicine Turkey 42(3), pp. 343-345

Sebaceous carcinoma, typically originating from the meibomian glands of the eyelids, is a rare malignant tumor with a propensity for diffuse, invasive growth. Intracranial extension of this carcinoma is exceptionally rare, with only a few cases reported. Here, we present an uncommon case of sebaceous carcinoma with extension to the cavernous sinus, Meckel's cave, and the temporal lobe. The patient underwent surgery and radiotherapy, resulting in regression of the tumor. However, a secondary meningioma associated with prior radiotherapy was identified on follow-up imaging. Regular monitoring is crucial for early detection of recurrent or metastatic disease. The necessity of optimal patient care through multidisciplinary collaboration in managing complex cases is highlighted in this report. Close follow-up and individualized treatment planning are essential for ensuring the best outcomes in such cases.

6. Accuracy of Deep Brain Stimulation Lead Placement Using a Cranial Robotic Guidance Platform: A Preliminary Cadaveric Study Biceroglu, H., Akbulut, B.B., Derin, O., (...), Acarer, A., Yurtseven, T. 2025 Turkish Neurosurgery 35(4), pp. 580-586

AIM: To measure the deviation rate of a custom 3D-printed Deep Brain Stimulation (DBS) lead holder assisted electrode placements from their intended targets, providing a benchmark for the system's accuracy and paving the way for its use in standard DBS workflows. MATERIAL and METHODS: The study was conducted in an experimental lab using a cadaver obtained according to local regulations. Planned electrode trajectories, designed with Medtronic's DBS surgery planning system, were transferred to the StealthStation Autoguide. A 3D-printed DBS lead holder with integrated navigation fiducials was used to place six electrodes in the targeted brain regions. Pre-operative CT and MRI scans were used for planning, and post-operative imaging confirmed electrode placement. Deviation from planned trajectories was analyzed using Python to assess accuracy. RESULTS: Following a 30-minute registration and draping process, the median electrode placement time was 22.5 minutes (range: 15-120). The total surgical time for all six electrodes was approximately 5 hours, including imaging, adjustments, and confirmation. The median difference was 1.73 mm (0.03-5.45) on the X-axis, 1.86 mm (0.46-2.74) on the Y-axis, and 1.95 mm (0.73-4.4) on the Z-axis. The median vectorial difference was 2.68 mm (2.3-6.71), while the median trajectory difference was 3.01 mm (1.64-6.63). CONCLUSION: Despite 50% of leads having a vectorial difference exceeding 4 mm, most had a trajectory difference of less than 3 mm, which could be attributed to the inability to measure the length of the electrode precisely. These results suggest that with minor adjustments, the StealthStation Autoguide could be a cost-effective alternative to similar systems, though further cadaveric studies are necessary to address potential learning curves and random factors.

7. Endovascular management of a persistent primitive trigeminal artery aneurysm initially misdiagnosed as pituitary adenoma: A Case Report Erol, A., Akbulut, B.B., Çinar, C., (...), Yurtseven, T., BiÇeroğlu, H. 2025 Journal of Experimental and Clinical Medicine Turkey 42(1), pp. 89-91

Persistence of primitive intracranial embryonic anastomoses such as the permanent primitive trigeminal artery (PPTA) is rare, with the PPTA representing 80-85% of these cases. Aneurysms associated with PPTA are rare. This presents diagnostic and therapeutic challenges. We report a 64-year-old woman, initially evaluated for headache and dizziness, where cranial computed tomography (CT) incidentally suggested a hypodense sellar lesion. Subsequently, on CT angiography, a 9 mm saccular aneurysm in the PPTA and an 18 mm aneurysm in the right internal carotid artery (ICA) cavernous segment were identified. Endovascular treatment with flow diverter stent implantation was successfully performed, followed by post-operative ticagrelor and acetylsalicylic acid therapy. The patient was discharged neurologically intact after three days of care in the hospital and there was no deterioration in neurological examination at 1-year follow-up. This case underscores the necessity of careful angiographic evaluation in patients with suspected pituitary masses to avoid potentially catastrophic misdiagnoses. It also highlights the critical role of imaging techniques in identifying rare vascular anomalies.

8. C7 pedicle vs. lateral mass screws in cervical spondylotic myelopathy: A retrospective analysis of cervical alignment parameters Bölük, M.S., Akbulut, B.B., Çenberlitaş, E.E., Biçeroğlu, H., Yurtseven, T. 2025 Journal of Experimental and Clinical Medicine Turkey 42(1), pp.14-19

Cervical spondylotic myelopathy (CSM) frequently requires surgical intervention at C7, with the choice between pedicle and lateral mass screws influencing outcomes. Pedicle screws offer superior biomechanical stability but carry higher neurovascular risks, while lateral mass screws are safer but less stable. Limited data compare these techniques in CSM treatment, particularly without O-arm navigation. To compare the safety, efficacy, and spinal alignment outcomes of C7 pedicle screws versus lateral mass screws in CSM patients, especially in settings lacking advanced imaging technologies. This retrospective cohort study analyzed 23 patients (13 with lateral mass screws, 10 with pedicle screws) who underwent posterior fusion surgery for CSM between 2013 and 2022. Preoperative and postoperative CT scans and a minimum one-year follow-up were required. Radiological parameters, including C2 slope, T1 slope, C2-7 Cobb angle, and sagittal vertical axis (SVA), were assessed, along with complications such as screw loosening, breakage, and revision surgeries. No significant differences were found between the two groups in screw loosening (69.2% vs. 60%), breakage (7% vs. 20%), or distal junctional kyphosis rates (7.7% vs. 0%). Both groups demonstrated similar improvements in spinal alignment parameters at postoperative and one- year follow-ups. One patient in the pedicle group required revision for a major foraminal breach, while three patients in the lateral mass group underwent revision for proximal junctional kyphosis. Both pedicle and lateral mass screws provided comparable safety, efficacy, and alignment outcomes at C7 in CSM patients. The choice of screw type should depend on patient anatomy, surgeon preference, and the availability of imaging technology.

9. Novel Barium-Enhanced 3-Dimensional-Printed Spine Model for Pedicle Screw Training: A Cost-Effective Solution and Educational Validation Bölük, M.S., Akbulut, B.B., Yurtseven, T., Biçeroğlu, H. 2025 Operative Neurosurgery 1602

BACKGROUND AND OBJECTIVES:Training in pedicle screw placement is crucial for neurosurgery residents, yet access to high-fidelity training models is often limited by cost and availability. This study introduces a novel, cost-effective barium-enhanced 3-dimensional (3D)-printed L4-5 spine model visible under fluoroscopy, aiming to validate its effectiveness as a training tool for novice residents in pedicle screw placement.METHODS:A barium-enhanced 3D-printed L4-5 spine model was developed to simulate human bone density and provide radiopacity under fluoroscopy. Ten neurosurgery residents with no prior experience in pedicle screw placement participated in a structured training program using this model. Each resident completed three training sessions, placing four pedicle screws per session, totaling 120 screw placements. Surgical duration, screw placement accuracy, and fluoroscopy usage were recorded. Screw placement accuracy was assessed by two independent blinded evaluators using both a visual grading method and the computed tomography-based Gertzbein-Robbins classification.RESULTS:The analysis demonstrated significant improvement in surgical time across sessions (P <.0001), decreasing from 20:44 ± 4:32 minutes to 13:17 ± 4:04 minutes. The median number of fluoroscopic images decreased from 8.5 (range: 5-18) to 6.0 (range: 5-10), although not statistically significant (P =.312). Visual assessment scores improved, with median breach scores decreasing from 0.25 (0.00-3.00) to 0.00 (0.00-0.25). Similarly, the median Gertzbein-Robins grades improved from 0.50 (0.12-2.88) to 0.12 (0.00-0.62). Visual and computed tomography-based assessments showed excellent correlation (intraclass correlation coefficients = 0.978, 95% CI: 0.953-0.989, P <.001).CONCLUSION:The barium-enhanced 3D-printed spine model ($1.61/session) provides a highly cost-effective training tool for novice residents, demonstrating significant improvements in surgical efficiency. Although accuracy measures showed promising trends, more extensive studies may be needed to establish definitive improvements in placement precision. The model's radiopacity allows for realistic fluoroscopic imaging, bridging the gap between basic models and more expensive alternatives, which is particularly valuable in resource-limited settings.

10. Evaluation of patients with traumatic vertebral fractures and accompanying rib fractures in terms of complication development and need for surgery | [Travmatik vertebra kırıkları ve eşlik eden kot kırıkları olan hastaların komplikasyon gelişimi ve cerrahi ihtiyacı açısından değerlendirilmesi] Kiraz, İ., Özgür, G.K., Akçam, T.İ., Biçeroğlu, H. 2025 Turkish Journal of Thoracic and Cardiovascular Surgery 33(1), pp. 86-93

Background: The aim of this study was to evaluate patients with traumatic vertebral fractures and accompanying rib fractures in terms of complication development and need for surgery. Methods: Between January 2019 and September 2022, a total of 173 patients (138 males, 35 females; mean age: 53.0±18.5 years; range, 17 to 95 years) who had vertebral and accompanying rib fractures due to blunt and penetrating trauma were retrospectively examined. The patients were divided into three groups: upper cervical (n=8), lower cervical (n=31), and thoracolumbar (n=134). Among the groups, trauma mechanisms, rib fracture numbers, accompanying thoracic pathologies, complication developments, and need for surgery were compared. Results: There was a significant difference between men and women in terms of trauma mechanisms (p=0.001). The mean number of accompanying rib fractures was 5.03±3.19. Number of accompanying rib fractures was higher in patients who developed complications compared to those who did not develop complications (p=0.007). Accompanying hemothorax was significantly higher in patients with upper cervical vertebral fractures (p=0.019). Need for spinal surgery to be significantly higher in patients with upper cervical vertebral fractures (p<0.01). Development of complications was higher in patients with burst fracture than in those without (p=0.004). There was a significantly higher need for spinal surgery in patients with burst fractures and lamina fractures (p<0.001 for both). Conclusion: Identification of risk groups is critical for the management of trauma patients. The type and level of vertebral fractures are related to the presence of hemothorax, the development of complications, and the need for surgery.

11. In Reply: Novel Barium-Enhanced 3-Dimensional-Printed Spine Model for Pedicle Screw Training: A Cost-Effective Solution and Educational Validation Akbulut, B.B., Bölk, M.S., Yurtseven, T., Biçeroğlu, H. 2025 Operative Neurosurgery 10.1227/ons.0000000000001737

12. Responsiveness and Minimal Clinically Important Difference of the Turkish Version of the Oswestry Disability Index in Patients With Acute Discogenic Lumbar Radiculopathy Celenay, S.T., Secer, E., Biceroglu, H., Ozer Kaya, D. 2025 Perceptual and Motor Skills

This study aimed to determine the responsiveness and establish the minimal clinically important difference of the Turkish version of the Oswestry Disability Index (ODI-TR) in patients with acute discogenic lumbar radiculopathy (ADLR). This study included 140 patients (mean age: 51.38 ± 12.23 years) with ADLR. Pre- and post-treatment, participants completed the ODI-TR and the Visual Analogue Scale (VAS), which assessed pain at rest (VASr), at night (VASn), and during activity (VASa). Post-treatment, the Global Perceived Effect Scale (GPE) was utilized to quantify patient-reported improvement or deterioration. Responsiveness was evaluated using both distribution- and anchor-based methods. The distribution-based approach involved calculating the standard error of measurement (SEM) using the formula SEM = SDx$\sqrt{}$(1-R), followed by the determination of the minimum detectable change at a 95% confidence level (MDC95), calculated as MDC = SEMx1.96x$\sqrt{}$2. The anchor-based method employed receiver-operating characteristic (ROC) curve analysis. The ODI-TR demonstrated good responsiveness, as indicated by an effect size of 1.29 and a standardized response mean of 1.03. The measurement error was quantified by an SEM of 7.08, and the MDC was calculated as 19.62. The ROC analysis showed a moderate ability to distinguish between patient outcomes, with an area under the curve of 0.71. An ODI-TR score of 9.50 was found to be the most effective cut-off, providing high sensitivity (86.1%) and specificity (76.0%). The ODI-TR is responsive in determining the changes in ADLR patients. The MDC and established cut-off point provide clinicians with valuable metrics for discerning clinically significant improvements or deteriorations.

13. Development and validation of a cost-effective three-dimensional-printed cervical spine model for endoscopic posterior cervical foraminotomy training: a prospective educational study from Turkey Akbulut, B.B., Çenberlitaş, E.E., Bölük, M.S., Yurtseven, T., Biçeroğlu, H. 2025 Asian Spine Journal 19(2), pp. 183-193

Study Design: Expanding upon established surgical simulation methods, we developed a fused deposition modeling three-dimensional (3D)-printed model of the C1–T1 vertebra for posterior cervical foraminotomy training that features silicone-based neural elements, polyurethane foam-based ligaments, and polyethylene terephthalate glycol vertebrae. Purpose: This study evaluated the effectiveness of a cost-efficient 3D-printed training model designed to help neurosurgical residents acquire fundamental skills in endoscopic posterior cervical foraminotomy while addressing the technique's challenging learning curve and limited training resources. Overview of Literature: Only a few studies have investigated the efficacy of such a model. Methods: Eight neurosurgery residents each with over 2 years of training completed four training sessions on two randomly assigned cervical spine levels using the newly developed 3D-printed model. A simple plumbing endoscope was used for real-time surgical visualization. Results: Among the 64 completed surgical levels, left-sided procedures showed significantly higher insufficient decompression rates than did right-sided procedures (25.0% vs. 3.6%, p =0.002). However, no significant difference in overall complication rates was observed between sides (p =0.073). Surgical parameters remained consistent across sides, with no significant differences in operative duration. Brunner-Langer analysis revealed substantial improvements in operative duration (mean duration decrease from 21:42±2:15 to 6:33±0:42 minutes, p =0.004) and total complications (mean decrease from 2.1±0.8 to 0.4±0.5, p =0.007) across sessions. Although fluoroscopy timing showed marginal improvement (mean duration decrease from 2:12±1:15 to 0:55±0:23 minutes, p =0.057), the number of fluoroscopic images tended to decrease. Conclusions: Our findings suggest that this novel 3D-printed cervical spine model could be a viable, low-cost option for neurosurgical training programs aiming to help residents develop essential endoscopic skills in a controlled setting. Facilitating early proficiency in posterior cervical foraminotomy can serve as a valuable intermediate step before transitioning to cadaveric models and clinical practice.

14. Endoscopic Endonasal Management of Cavernous Sinus Hemangioma: A Case Report Akhbari, M., Bahadır Akbulut, B., Serdar Bölük, M., Yurtseven, T., Biçeroğlu, H. 2025 Iranian Journal of Neurosurgery 11,E15

Background and Aim: Cavernous sinus hemangiomas (CSH) are rare benign vascular tumors that can result in headaches, visual disturbances, and cranial nerve palsies due to their location within the cavernous sinus. Case Presentation: A 56-year-old woman presented with a headache and blurred vision persisting for the last 3 months. There were no previous surgeries, allergies, or known diseases. Upon admission, a neurological examination revealed no cranial nerve involvement, motor or sensory deficits, or other vision disturbances. Cranial magnetic resonance imaging (MRI) was obtained, which showed a 16.1×17.9 mm T2 hyperintense lesion in the cavernous sinus. Endoscopic endonasal transsphenoidal was used for the removal of the tumor. Post-operative MRI revealed total removal of the tumor. Histopathological analysis confirmed the lesion to cavernous sinus hemangioma. There were no complications or recurrences during the 6-month follow-up. Conclusion: This case demonstrates the successful application of endoscopic endonasal transsphenoidal surgery (EETS) for the complete resection of cavernous sinus hemangioma.

15. Factors Contributing to Survival of IDH Negative Glioblastomas according to WHO 2021 Classification: Is Resection Extent Relevant? Erkin Özgiray; Nevhis Akıntürk; Bilal Bahadır Akbulut; Ömer Kitiş; Yeşim Ertan; Tayfun Çağrı Hidimoğlu; Serra Kamer; Kadri Emre Çalışkan; Mustafa Serdar Bölük; Hüseyin Biçeroğlu; Mehmet Sedat Çağlı; Taşkın Yurtseven Brain and Spine, January 01, 2024, Volume 4, Article 103550, Conference: EANS Sofia 2024

Background: In 2021, the World Health Organization reclassified IDH-negative gliomas as glioblastomas. Although the positive effect of extensive surgery on survival in high-grade glial tumors is known, the relationship between residual tumor volume and prognosis in this subgroup (IDH-negative) has not been well addressed yet. This study aims to determine whether the extent of resection significantly impacts survival in IDH-negative gliomas. Methods: The adult patients with IDH-negative glioblastoma operated in our tertiary care center between July 2018 - August 2022 were analyzed retrospectively. Patients who didn't receive adjuvant therapy or lacked postoperative imaging were excluded. Demographic data, survival, American Society of Anaesthesiologists (ASA) score, and modified Rankin score (mRS) were collected. Tumor and residual tumor volumes were measured using Eclipse (v18.0) radiotherapy planning software, and the residual tumor percentage was calculated accordingly. Results: 52 patients were enrolled in this study, with 26 males and a median age of 64.5 (interquartile range(IQR)=15.75) (Table 1). The median survival time was 8 (IQR= 14.65) months. The preoperative mRS score had a median of 2.5 (IQR=2); postoperatively, it was 3 (IQR=3). The preoperative and postoperative mean tumor volumes were 45.9±29.7 and 6.6±10.3 cm3, respectively. The mean residual tumor percentage was 12.9± 14.5%. Statistical analysis showed that survival was inversely correlated with age(-.386, p=0.005) and residual tumor percentage (-.354, p=0.01). A 95% and above tumor excision rate was associated with improved outcomes compared to excision rates <95%, resulting in 60% to 30% survival at 12 months, respectively. ASA score, mRS, and preoperative tumor volume didn't affect survival. Conclusions: In this study, the extent of resection significantly affected the survival rate of IDH-negative glioblastomas. Gross total tumor removal is crucial for more prolonged survival.

16. An Uncommon Occurrence of Posterior Fossa Ependymoma in Elderly Patient: A Case Report | [Posterior Fossa Ependimomunun Yaşlı Hastada Nadir Bir Prezentasyonu: Olgu Sunumu] Akbulut, B.B., Biçeroğlu, H., Bölük, M.S., Yurtseven, T. 2024 Duzce Medical Journal 26(3), pp. 279-281

Cerebellar ependymomas are rare neoplasms, even more so in elderly patients. In this case report, a 75-year-old male patient admitted with a one-year history of progressive general decline, urinary retention, left-sided weakness, memory loss, and insomnia was presented. Physical examination revealed left-sided hemiparesis and mild confusion. Cranial magnetic resonance imaging (MRI) showed a heterogeneously enhancing lesion measuring 22x15x20 mm originating from the fourth ventricle, with signs of hydrocephalus. The patient underwent tumor resection and placement of a ventriculoperitoneal (VP) shunt to address hydrocephalus. Postoperative MRI revealed no residual tumor, and the patient experienced gradual clinical improvement. Hemiparesis showed partial recovery, the overall condition stabilized, and he was subsequently discharged. Pathological examination confirmed a diagnosis of World Health Organization (WHO) grade II ependymoma. The patient is currently on a three-month follow-up.

17. Pain intensity, spine structure, and body composition in patients with acute discogenic lumbar radiculopathy Kaya, D.O., Celenay, S.T., Secer, E., Biceroglu, H.2024 Musculoskeletal Science and Practice 73,103133

Objective: This study aimed to compare the pain intensity, spine structure, and body composition according to functional disability levels in patients with acute discogenic lumbar radiculopathy (DLR). Methods: A total of 118 women (n = 83) and men (n = 35) patients with acute DLR (mean age: 51.87 ± 13.38 years) were included in the study. The function ability was measured with the Oswestry Disability Index, pain intensity was measured with the Visual Analogue Scale, spine structure was measured with the Spinal Mouse® device, and body composition was measured with the Bioelectrical Impedance Analysis System. Results: Patients with mild functional disability levels had significantly lower activity (p<.001) and night pain intensity (p = 0.001) than patients with moderate, severe, and completely functional disability levels, and patients with completely functional disability levels had significantly higher rest pain intensity (p = 0.005) than patients with mild, moderate, and severe functional disability levels. Patients with mild functional disability levels had significantly better spine check scores (p = 0.001), posture (p = 0.005), and mobility (p = 0.003) than patients with moderate, severe, and completely functional disability levels. Patients with mild functional disability levels had significantly lower fat percentage (p = 0.032), and higher basal metabolic rate (p = 0.024) than patients with moderate, severe, and completely functional disability levels. Conclusion: Pain intensity, spinal structure, and body composition of acute DLR patients differ greatly according to their functional disability levels. Although it is known that the level of functional disability of patients is a result of the severity or prognosis of the disease, performing different treatment methods aimed at decreasing the functional disability level of patients by health professionals may be important in terms of coping with the disease.

18. Management of intracranial angiosarcoma metastasis to the right lateral ventricle choroid plexus by radiotherapy: A case report Akbulut, B.B., BiÇeroğlu, H., Bölük, M.S., Yurtseven, T. 2024 Journal of Experimental and Clinical Medicine Turkey 41(3), pp. 679-680

Angiosarcomas are a type of rare malignant endothelial tumor. While its most common metastasis site is the scalp, cerebral metastases are rare. A 46-year-old woman came with a headache. A cranial magnetic resonance imaging (MRI) showed a hemorrhagic lesion within the right lateral choroid plexus and T1 contrast-enhancing lesions in the falx cerebri and right frontal dura. We used mini-craniotomy and neuronavigation to remove a purple-colored extradural lesion in the right frontal region. Histopathological analysis later confirmed the diagnosis of angiosarcoma. Cardiac MRI demonstrated the presence of a left atrial mass, which led to the decision to operate on the patient by the cardiovascular surgery team. After the surgery, the patient underwent radiotherapy and chemotherapy, as there was no cranial metastasis necessitating surgical resection. The cranial metastases responded to the treatment on follow-up, and there was no evidence of recurrence on the three-year follow-up. Although they are uncommon, pathology that indicates the presence of angiosarcoma requires cardiac screening. These patients may not require aggressive surgery as they respond well to adjuvant therapies.

19. Evaluating the efficacy of a cost-effective, fully three-dimensional-printed vertebra model for endoscopic spine surgery training for neurosurgical residents Akbulut, B.B., Bölük, M.S., Biçeroğlu, H., Yurtseven, T. 2024 Asian Spine Journal 18(5), pp. 630-638

Background and Importance: Low-grade gliomas (LGGs) in the infratentorial region are rare in adults. Case Presentation: A 31-year-old man presented with a 2-year history of neck pain and progressive numbness in the face and left arm. Neurological examination upon admission revealed no cranial nerve involvement, motor or sensory deficits, or signs of cerebellar dysfunction. The patient's medical history was unremarkable. Cranial magnetic resonance imaging (MRI) revealed a 2-cm T2 hyperintense lesion with focal cystic components in the right cerebellar tonsil, suggestive of a LGG. The lesion was surgically removed without any complications. Post-operative MRI showed total removal of the tumor. Histopathological analysis confirmed the lesion to be a pilocytic astrocytoma. No adjuvant therapy was given, and the patient is recurrence-free at 1-year follow-up. Conclusion: This case underlines the possibility of such rare diagnoses in adult patients and the effectiveness of the surgical treatment.

20. Investigating the effects of PTEN mutations on cGAS-STING pathway in glioblastoma tumours Dogan, E., Yildirim, Z., Akalin, T., (...), Kosova, B., Bozok, V. 2024 Journal of Neuro Oncology 166(2), pp. 283-292

Background and Aim: Intramuscular myxomas are uncommon benign tumors that are rarely seen in the paraspinal musculature. They might present with neurological symptoms if situated near the spinal cord or may present with nonspecific symptoms such as back pain. Case Presentation: The case of this study was a 46-year-old female presented with back pain that was exacerbated with movement. A thoracolumbar magnetic resonance imaging (MRI) revealed a T2 hyperintense 35×25×85 mm mass that extends craniocaudally within the right-sided paraspinal muscles with heterogeneous contrast enhancement on T1 sequence images. Using a paramedian incision, paraspinal muscles were dissected, and a rubbery mass was palpated within. The tumor was mobilized in all quadrants and removed with its pseudocapsule. The tumor internally had a gel-like substance with rubbery margins. The patient was discharged without complications. Conclusion: To our knowledge, this is the 16th case of paraspinal intramuscular myxoma in the literature. Even though it is a rare entity, one must be vigilant for pathologies within the paraspinal muscles in patients with back pain.

21. Rare Presentation of Pilocytic Astrocytoma in the Cerebellar Tonsils of an Adult: A Case Report Akbulut, B.B., Bölük, M.S., Yurtseven, T., Biçeroğlu, H. 2024 Iranian Journal of Neurosurgery 10,E26

Study Design: A fused deposition modeling three-dimensional (3D)-printed model of the L4–5 vertebra for lumbar discectomy was designed. The model included separately printed dura mater, spinal cord, ligamentum flavum, intervertebral disc (from thermoplastic polyurethane), and bony structures (from polylactic acid), and the material cost approximately US$ 1 per model. A simple plumbing endoscope was used for visualization. Dura mater injury was assessed by painting two layers on the dura mater, which peeled off with trauma. Purpose: Endoscopic spine surgery is a subject of high interest in neurosurgery given its minimally invasive nature; however, it has a steep learning curve. This study evaluated the effectiveness of a cost-efficient 3D-printed model when teaching this technique to neurosurgery residents. Overview of Literature: Only a few studies have investigated the efficacy of such a model. Methods: Eight residents with >2 years of training participated. Residents performed the procedure bilaterally and twice at 1-week intervals. Results: From the 32 surgeries, four were excluded because of facet removal (as it widened the surgical corridor), leaving 28 surgeries for analysis. Initial surgeries demonstrated a mean operation time of 21 minutes 18 seconds (standard deviation [SD], 2 minutes 32 seconds), which improved to a mean of 6 minutes 45 seconds (SD, 37 seconds) in the fourth surgery ($F(3, 17)=19.18$, $p <0.0001$), demonstrating a significant reduction in surgical time over successive surgeries. The median area with the paint removed decreased, from 161.80 (85.55–217.83) to 95.13 mm2 (12.62–160.54), ($F(2.072, Inf)=2.04$, $p =0.128$); however, this was not significant. Resident feedback indicated high satisfaction with the educational value of the model. Conclusions: The developed fully 3D-printed model provides a viable and scalable option for neurosurgical training programs, enhancing the learning experience while maintaining low costs. This model may be an excellent stepping stone for learning lumbar spine endoscopy, acclimating to the two-dimensional view, progressing to cadaver models, and, eventually, independent surgery.

22. Addressing silicone ventriculoperitoneal shunt hypersensitivity with teflon sheets: a case report Biçeroğlu, H., Akbulut, B.B., Turhan, T., Yurtseven, T. 2024 Wound Practice and Research 32(4), pp. 200-203

Background: PTEN is a tumour suppressor gene and well-known for being frequently mutated in several cancer types. Loss of immunogenicity can also be attributed to PTEN loss, because of its role in establishing the tumour microenvironment. Therefore, this study aimed to represent the link between PTEN and cGAS-STING activity, a key mediator of inflammation, in tumour samples of glioblastoma patients. Methods: Tumour samples of 36 glioblastoma patients were collected. After DNA isolation, all coding regions of PTEN were sequenced and analysed. PTEN expression status was also evaluated by qRT-PCR, western blot, and immunohistochemical methods. Interferon-stimulated gene expressions, cGAMP activity, CD8 infiltration, and Granzyme B expression levels were determined especially for the evaluation of cGAS-STING activity and immunogenicity. Results: Mutant PTEN patients had significantly lower PTEN expression, both at mRNA and protein levels. Decreased STING, IRF3, NF-KB1, and RELA mRNA expressions were also found in patients with mutant PTEN. Immunohistochemistry staining of PTEN displayed expressional loss in 38.1% of the patients. Besides, patients with PTEN loss had considerably lower amounts of IFNB and IFIT2 mRNA expressions. Furthermore, CD8 infiltration, cGAMP, and Granzyme B levels were reduced in the PTEN loss group. Conclusion: This study reveals the immunosuppressive effects of PTEN loss in glioblastoma tumours via the cGAS-STING pathway. Therefore, determining the PTEN status in tumours is of great importance, like in situations when considering the treatment of glioblastoma patients with immunotherapeutic agents.

23. Thoracolumbar Paravertebral Intramuscular Myxoma Presenting With Mechanical Back Pain: A Case Report and Review of the Literature Akbulut, B.B., Biçeroğlu, H., Akalın, T., Bölük, M.S., Yurtseven, T. 2024 Iranian Journal of Neurosurgery 10,E5

Ventriculoperitoneal (VP) shunts, used to treat hydrocephalus, can sometimes cause hypersensitivity reactions to silicone, necessitating repeated surgical interventions. Traditional management involves replacing silicone with alternatives like polyurethane, which have limitations. This study presents a novel approach using Teflon (PTFE) sheets to cover the silicone valve surface. A 22-year-old male with a history of multiple shunt surgeries and wound revisions was admitted for wound dehiscence, suspected to be due to a late hypersensitivity reaction to silicone. The shunt valve and cranial entry point were wrapped in Teflon PTFE felt sheets, and the wound was closed with propylene sutures. The patient was treated with methylprednisolone and discharged after three days. Follow-up showed complete wound healing within a month, and the patient remained revision-free for ten years. This case suggests that Teflon sheets may offer a promising approach for managing silicone hypersensitivity in VP shunts, though further studies are needed to determine its broader applicability.

24. Subdural Empyema Caused By Brucellosis: A Case Report And Review Of The Literature Volume: 13 Issue: 1 P: 6 – 6 January 2024 Mediterr J Infect Microb Antimicrob 2024;13(1):6-6 Doı: 10.4274/Mjima.Galenos.2024.24152.6 Bilal Bahadır Akbulut , Anıl Erol , Mustafa Serdar Bölük , Taşkın Yurtseven , Cenk Eraslan , Bilgin Arda , Hüseyin Biçeroğlu

Brucellosis, a zoonotic infection caused by a bacteria of the Brucella genus, is a significant public health problem worldwide. It is predominantly encountered in the Mediterranean basin, Arabian Peninsula, India, Mexico, and South America[1]. The disease is transmitted to humans via the consumption of unpasteurized dairy products or a direct contact with infected animals. Brucellosis is an infectious disease that presents with fever, malaise, night sweats, and arthralgias. It can involve multiple organs and is a major diagnostic and therapeutic issue. Although rare, neurobrucellosis may present with a subdural empyema, which warrants evacuation. A hyperdense rim around a collection on CT and contrast-enhanced MRI is a warning sign of neurobrucellosis. Thus, a preoperative MRI should be obtained if there is a clinical suspicion of neurobrucellosis and the patient's status is suitable.

25. Cureus 2024 Aug 20;16(8):e67320. doi: 10.7759/cureus.67320. eCollection 2024 Aug. A Case of Carcinoma Metastasis of Unknown Primary Mimicking Spondylodiscitis in an HIV+ Patient Anıl Erol , Khassan Saidazimov , Mustafa Serdar Bölük , Taşkın Yurtseven , Hüseyin Biçeroğlu PMID: 39301346 PMCID: PMC11412647 DOI: 10.7759/cureus.67320

In this case report, a case of carcinoma metastasis of unknown primary mimicking spondylodiscitis in a patient with acquired immunodeficiency syndrome (AIDS) is presented. A 50-year-old AIDS patient presented with a history of mechanical falls from his own level one month ago and leg weakness for the last three days. Spinal magnetic resonance imaging (MRI) revealed a compression fracture of the T4 vertebral body, spinal cord compression, and pathology compatible with spondylodiscitis. Posterior decompression and fusion were performed, and the patient benefited. The preoperative ASIA score was C, and the postoperative ASIA score was D. The sample taken from the lesion for pathology showed carcinoma metastasis. Tumor markers and whole-body computed tomography (CT) and MRI results did not support primary malignancy. Positron emission tomography was planned for further evaluation but could not be performed due to the poor general condition of the patient. During follow-up, the patient died of sepsis due to an intensive care unit infection. As new cases of carcinoma metastasis mimicking spondylodiscitis in AIDS patients are added to the literature, we will have more information about the diagnosis and treatment process.

26. Double Trouble – An Anterior Clinoidal Meningioma with a Concurrent Right MCA Aneurysm Akbulut, Bilal Bahadır; Erol, Anıl; Bölük, Mustafa Serdar; Yurtseven, Taşkın; Biçeroğlu, Hüseyin Neurologico Spinale Medico Chirurgico 7(1):p 65-67, Jan–Apr 2024. | DOI: 10.4103/nsmc.nsmc_6_24

Although meningiomas and cerebral aneurysms are common intracranial pathologies, their coexistence in one patient is rare. We present a case of right anterior clinoid meningioma that has a concurrent right middle cerebral artery (MCA) aneurysm. A 55-year-old female complaining of right-sided visual loss was admitted to our department after magnetic resonance imaging (MRI) revealed a right anterior clinoid meningioma that was extending to sella turcica and expanded superiorly, compressing the optic chiasm. With a plan of transnasal transsphenoidal endoscopic excision, a preoperative computed tomography angiogram was obtained, per our protocol. This revealed an incidental 3 mm right MCA bifurcation aneurysm. Due to the possibility of postoperative aneurysm bleeding, the patient was operated on with a right-sided pterional craniotomy. After 5 days of postoperative follow-up, the patient was discharged without complications. The histopathological analysis confirmed the diagnosis of psammomatous meningioma. This case underlines the importance of preoperative planning and being vigilant for incidental findings that might cause fatal consequences.

27. The Effect of Preoperative Three Dimensional Modeling and Simulation on Outcome of Intracranial Aneursym Surgery Ozgıray, E., Husemoglu, B., Cınar, C., (...), Bıceroglu, H., Kızmazoglu, C. 2024 Journal of Korean Neurosurgical Society 67(2), pp. 166-176

Objective: Three-dimensional (3D) printing in vascular surgery is trending and is useful for the visualisation of intracranial aneurysms for both surgeons and trainees. The 3D models give the surgeon time to practice before hand and plan the surgery accordingly. The aim of this study was to examine the effect of preoperative planning with 3D printing models of aneurysms in terms of surgical time and patient outcomes. Methods: Forty patients were prospectively enrolled in this study and divided into two groups: groups I and II. In group I, only the angiograms were studied before surgery. Solid 3D modelling was performed only for group II before the operation and was studied accordingly. All surgeries were performed by the same senior vascular neurosurgeon. Demographic data, surgical data, both preoperative and postoperative modified Rankin scale (mRS) scores, and Glasgow outcome scores (GOS) were evaluated. Results: The average time of surgery was shorter in group II, and the difference was statistically significant between the two groups ($p<0.001$). However, no major differences were found for the GOS, hospitalisation time, or mRS. Conclusion: This study is the first prospective study of the utility of 3D aneurysm models. We show that 3D models are useful in surgery preparation. In the near future, these models will be used widely to educate trainees and pre-plan surgical options for senior surgeons.

28. Molecular dynamic simulation and functional analysis of pathogenic PTEN mutations in glioblastoma Cetintas, V.B., Duzgun, Z., Akalin, T., (...), Ertan, Y., Kosova, B. 2023 Journal of Biomolecular Structure and Dynamics 41(21), pp. 11471-11483

PTEN, a dual-phosphatase and scaffold protein, is one of the most commonly mutated tumour suppressor gene across various cancer types in human. The aim of this study therefore was to investigate the stability, structural and functional effects, and pathogenicity of 12 missense PTEN mutations (R15S, E18G, G36R, N49I, Y68H, I101T, C105F, D109N, V133I, C136Y, R173C and N276S) found by next generation sequencing of the PTEN gene in tissue samples obtained from glioblastoma patients. Computational tools and molecular dynamic simulation programs were used to identify the deleterious effects of these mutations. Furthermore, PTEN mRNA and protein expression levels were evaluated by qRT-PCR, Western Blot, and immunohistochemistry staining methods. Various computational tools predicted strong deleterious effects for the G36R, C105F, C136Y and N276S mutations. Molecular dynamic simulation revealed a significant decrease in protein stability for the Y68H and N276S mutations when compared with the wild type protein; whereas, C105F, D109N, V133I and R173C showed partial stability reduction. Significant residual fluctuations were observed in the R15S, N49I and C136Y mutations and radius of gyration graphs revealed the most compact structure for D109N and least for C136Y. In summary, our study is the first one to show the presence of PTEN E18G, N49I, D109N and N276S mutations in glioblastoma patients; where, D109N is neutral and N276S is a damaging and disease-associated mutation. Communicated by Ramaswamy H. Sarma.

29. Computed tomography vs. Magnetic resonance imaging in unstable cervical spine injuries | [Anstabil servikal yaralanmalarda bilgisayarlı tomografi ve manyetik rezonans görüntüleme bulgularının karşılaştırılması] Kodik, M.S., Eraslan, C., Kitiş, Ö., (...), Biçeroğlu, H., Akay, A. 2020 Ulusal Travma Ve Acil Cerrahi Dergisi 26(3), pp. 431-438

BACKGROUND: This study aimed to investigate the role of computed tomography (CT) in identifying missed unstable blunt cervical injuries. METHODS: Patients admitted to the emergency department between June 2014 and June 2018 with a diagnosis of blunt cervical trauma were included in this study. All participants underwent cervical magnetic resonance imaging (MRI) after an initial cervical CT investigation. All imaging results were reviewed, and decisions were taken by the consensus of a team consisting of an emergency medicine specialist, a neuroradiologist, and a neurosurgeon. Other variables included age, sex, the Glasgow Coma Scale, medical comorbidities, multi-trauma, neurological deficits, accompanying intracranial hemorrhage, extremity fractures, and the mechanism of the injury. RESULTS: Data for 195 patients were analyzed. The mean (±standard deviation) age of the participants was 47.34±21.90 years, and 140 (71.8%) were males. Eighteen patients (9.2%) were below age <18. The most frequent mechanism of injury was fall from height (n=100; 51.3%). Using MRI as the gold standard, the sensitivity of CT in diagnosing unstable cervical injury was 77.7% (95% CI [67.1–86.1]), while its specificity was 100.0% (95% CI [59.0–100.0]). CONCLUSION: Although computed tomography is relatively good in diagnosing unstable cervical injuries, its sensitivity in detecting positive cases is not as successful. Thus, the use of MRI in patients with an unstable injury seems to be warranted.

30. Variations in Toll-like receptor and nuclear factor-kappa B genes and the risk of glioma Kına, I., Sultuybek, G.K., Soydas, T., (...), Uzan, M., Ulutin, T. 2019 British Journal of Neurosurgery 33(2), pp. 165-170

Purpose: Glioblastoma (GBM) is the most aggressive primary brain tumour in the adult nervous system and is associated with a poor prognosis. NF-KB activation is an important driver of the malignant phenotype that confers a negative prognosis in patients with GBM. NF-KB plays a role in Toll-like Receptors (TLR)-induced tumourigenesis. The aim of the present study was to investigate the association of a promoter region polymorphism of NFKB1 gene encoding the p50 subunit of NF-KB, namely -94ins/del ATTG, the most widely discussed the TLR2 Arg753Gln, TLR4Asp299Gly and TLR4Thr399Ile polymorphisms, their combined effects, and the glioma risk. Methods: A group of 120 Glioma patients and 225 control subjects were screened for these four polymorphisms using the PCR-RFLP method. Results: Statistical analysis indicates that the ins/ins genotype of NFKB -94ins/delATTG (p=0.003), and the AA genotype of TLR4Asp299Gly (p < 0.001) are risk factors for glioma and people carrying the ins allele have an approximately 1.47 times susceptibility risk of glioma whereas GG genotype of TLR2Arg753Gln seems to be protective against glioma (p = 0.002). Combined genotype analysis showed that del/ins-GG genotype of TLR2Arg753Gln-NFKB1, del/ins + GG genotype of TLR4Asp299Gly-NFKB1, del/ins-CC genotype of TLR4Thr399Ile-NFKB1 were risk factors for glioma development. Conclusion: NFKB1 -94ins/delATTG and TLR4Asp299Gly polymorphisms are associated with increased glioma cancer risk in a Turkish population.

31. The microsurgical anatomy of the anterior commissure | [Anterior Komissür Mikrocerrahi Nöroanatomisi] Baydin, Ş.S., Biçeroğlu, H. 2019 Gazi Medical Journal 30(4A), pp. 425-427

Aim: The third ventricle is a funnel-shaped cavity located deep in the brain and difficult to access with surgical approach. The anterior commissure is an anatomical structure located on the anterior wall of the third ventricle. This study aimed to demonstrate the use of the anterior interhemispheric transcallosal approaches to access the third ventricle, evaluate the microsurgical anatomy of the anterior commissure and investigate the morphological features of this region. Methods: Eleven cadaveric brain specimens were dissected using microsurgical tools. Different anterior interhemispheric routes to the third ventricle were demonstrated, and stepwise dissections were performed to expose the limbs of the anterior commissure. Morphological measurements of the anterior commissure and the third ventricle were carried out. Results: The anterior limb of the anterior commissure extends towards the anterior perforating substance, olfactory bulb, anterior olfactory nucleus and the orbitofrontal cortex. The posterior limb extends from the basal part of the caudate nucleus, passes below the substantia innominata and courses through the basal part of the putamen. It constitutes the major component of the anterior commissure and is composed of temporal and occipital fibers. The mean length of the anterior commissure body was 16.2 ± 4.2 (range 9.7–24.2) mm, while the mean width was 4.3 ± 0.7 (range 2.8–5.1) mm. Conclusion: A better understanding of the microsurgical anatomy and morphometric features of the third ventricle and anterior commissure increases the success of surgical interventions and prevents possible complications in this region.

32. Nazal Cerrahide Anatomik Temel İlkeler Ali KARADAĞ,Hüseyin BİÇEROĞLU Türk Nöroşirürji Dergisi2020 , Vol 30 , Num 1.

Endonazal teknikler, nöroşirürji alanında kafa tabanına yönelik yaklaşımlarda yoğun olarak kullanılan prosedürlerin başını çekmektedir. Her iki burun deliği boyunca, endoskopik ve mikroskopik olarak cerrahın görüş alanını artırmaya yarayan cihazlar geliştirilmiştir. Bu işlemlerin nazal aşamasında tıpkı mikrocerrahi teknikte olduğu gibi endoskopik tekniklerde de kılavuz olarak kullanılan önemli anatomik yapılar mevcuttur. Daha yakın zamanlarda, endoskopik cerrahi tekniklerin ve teknolojik gelişmelerin evrimi, sellar bölgeye ve kafa tabanına standart transsfenoidal yaklaşımın yanı sıra diğer endonazal çeşitli modifikasyonların geliştirilmesine yol açmıştır. Nitekim, bugün, bu yaklaşımlar esas olarak frontal sinüsten alt klivusa kadar orta hat ve kafa tabanını hedef almaktadır. Bu yazıda temel amacımız, endonazal bölgeyi ve belirli yaklaşımları anatomik temelde tanımlamaktır.

33. Neuroanatomical aspects of the Temporo-Parieto- occipital junction and new surgical strategy to preserve the associated tracts in junctional lesion surgery: Fiber separation technique Biceroglu, H., Karadag, A. 2019 Turkish Neurosurgery 29(6), pp. 864-874

Aim: The anterior comissure, that is a commissural fibers, connects frontal, temporal and occipital areas of the each hemispheres. Our aim is exposing the anterior commissure and it's segmantation's with white matter dissection technique in this study. Material and Method: Our study was performed eight human cadaver heads. Klingler's White matter dissections technique was used. Results: The anterior comissure was dissected from lateral and medial surface gradually. It locates on inferior and posterior of th erostrum of the corpus callosum on medial surface. Also, the anterior comissure is formed anterior border of the third ventricle. Dissection from lateral surface, it locates in the anterior base of lentiform nucleus obliquelly. The anterior commissure has five segments; corpus, anterior and posterior limb, temporal and occipital fibers. Discussion: The anterior-posterior commissure line, as bicommissural line is indispensable for surgery. In some cases, after callosotomy that uses epilepsy surgery, the resistans epileptic atacts still continue.The cause of this atacts is the anterior commissure and so it must be damaged during the callosotomy surgery. Conclusion: The white matter studies aid to better understand of the deep brain structures. Thus, we can perform the intraaxial surgeries more safely, and treat to the neuronal structires more kindly.

34. Comparison between Rescue Flap and Double Flap Technique Benzer, M., Biceroglu, H., Ates, M.S., (...), Karcl, B., Gode, S. 2019 Journal of Neurological Surgery Part B Skull Base 80(4), pp. 431-436

AIM: To describe the location of each white matter pathways around the temporo-parieto-occipital junction (TPOJ) and the dissections performed using focal fiber dissection and fiber separation techniques (FST). These areas play an important role in human language processing and high-level brain functions. Thus, it is important to identify the association of the fascicles as well as their courses to plan safe and effective surgical target vectors. MATERIAL and METHODS: Thirty formalin-fixed human hemispheres and two formalin-fixed human heads were dissected with focal fiber dissection and FST under 6-40× magnification using a surgical microscope and real-time magnetic resonance imaging navigation system. Two- and three-dimensional anatomical and surgical pictures were obtained and processed using high dynamic range photography (Photomatix) and were correlated to radiological images of the case with glioblastoma of the TPOJ. RESULTS: The trajectory and connectivity of these fibers as well as their surgical importance in performing FST in cadaver dissections were demonstrated with correlation of the surgical, radiological, and anatomical images. CONCLUSION: The microanatomy of the TPOJ and related structures, emphasizing the position of each white matter pathway, has been described. Understanding the composition of each region is critical in preventing intraoperative brain injury that could lead to functional deficits.

35. The Effect of Endoscopic Endonasal Transsphenoidal Skull Base Surgery on Cochlear Function Ates, M.S., Benzer, M., Kaya, I., (...), Karci, H.B., Gode, S.2019 Journal of Neurological Surgery Part B Skull Base 80(6), pp. 604-607

Endoscopic transsphenoidal skull base surgery (ETSS) has become a standard approach in the treatment of sellar and clival lesions, such as pituitary adenoma and chordoma. Due to the close proximity of the clivus and the sella turcica to the inner ear, it is thought that bone drilling in the surgery may have effects on hearing. The aim of this study was to assess the effect of bone drilling in ETSS procedure on cochlear function. This study was performed on 18 patients who underwent ETSS procedure between December 2016 and May 2017. The study was designed as a prospective study. All of the data were prospectively collected. These included demographic data, date of surgery, type of surgery, preoperative pure-tone audiometry, and preoperative and postoperative distortion product otoacoustic emission (DPOAE) measurements. Of the DPOAE measurements of the patients who were operated for pituitary adenoma, there was a statistically significant difference between the signal-to-noise ratio (SNR) measurements at 0.5, 1, 2 and 4 kHz ($p < 0.05$). Additionally, there were no significant differences in preoperative and postoperative SNR measurements of six patients who were selected for clivus chordoma. When the preoperative and postoperative tonal audiometric tests of the patients were compared, no statistically significant difference was found ($p > 0.05$). In conclusion, it is found that bone drilling in ETSS procedure has a negative effect on cochlear function in the early period. This is the first study to evaluate the degree of noise-induced cochlear damage in patients who were gone under ETSS procedure.

36. Creation of 3-Dimensional Life Size: Patient-Specific C1 Fracture Models for Screw Fixation Govsa, F., Ozer, M.A., Biceroglu, H., (...), Eraslan, C., Alagoz, A.K. 2018 World Neurosurgery 114, pp. e173-e181

Background: Transarticular screw fixation has fatal complications such as vertebral artery (VA), carotid artery, and spinal cord injuries. The landmarks for deciding the entry point for C1 lateral mass screws were clarified by using life-size 3-dimensional (3D) patient-specific spine models. Methods: This study included a total of 10 patients with C1 fractures. Dual-energy computed tomography (CT) scan data from C1 pre- and postscrewing were modified into 3D patient-specific life-size cervical spine models. The detailed information, such as bony and vascular elements, of 13 separate parameters of C1 was used as an intraoperative reference. Results: 3D patient-specific models were created preoperatively with the fracture and postoperatively with the screwed vertebrae. After CT scans of the models were measured, the life-size patient-specific models were proven to be individualized. 3D models assisted in determining the fracture locations, pedicle sizes, and positions of the VA. The range of the measurements for ideal point of entry reveals the need for patient-specific intervention was required. Conclusions: 3D models were used in surgical planning maximizing the possibility of ideal screw position and providing individualized information concerning cervical spinal anatomy. The individualized 3D printing screw insertion template was user-friendly, of moderate cost, and it enabled a radiation-free cervical screw insertion.

37. Preoperative Somatostatin Analogue Treatment Might Trigger Apoptosis and Autophagy in Tumor Tissues of Patients with Acromegaly: A Pilot Study Dagistanli, F.K., Ozkaya, H.M., Kucukyoruk, B., (...), Kadioglu, P., Ozturk, M. 2018 Experimental and Clinical Endocrinology and Diabetes 126(3), pp. 168-175

Objective: To evaluate the effect of preoperative somatostatin analog (SRL) treatment on proteins associated with apoptosis and autophagy in patients with acromegaly and to determine factors correlating with these parameters. Methods: Ex-vivo tumor samples of 11 SRL-treated and 9 SRL-untreated patients were retrospectively included in the study. Apoptotic and autophagic proteins were determined via immunohistochemical staining and apoptosis was evaluated via in situ DNA end labeling (TUNEL). Results: TUNEL, caspase-3, and ATG-5 immunopositivity was significantly increased ($p<0.01$, $p=0.01$, $p=0.01$, respectively), survivin and beclin-1 immunopositivity was significantly decreased ($p=0.03$, $p=0.02$, respectively) in SRL-treated patients as compared with SRL-untreated controls. Ki-67 index was decreased significantly in the SRL-treated group ($p=0.01$). Significant positive correlations were detected between TUNEL and caspase-3 immunopositivity ($r=0.577$, $p<0.01$), and between survivin and beclin-1 immunopositivity ($r=0.503$, $p=0.03$). Age at diagnosis, preoperative GH, IGF-1 levels, tumor size, and invasion status were not found to affect TUNEL positivity nor did they correlate with caspase-3, survivin, beclin-1, ATG-5 immunopositivity ($p>0.05$ for all). Preoperative SRL treatment was the only factor that had a significant effect on TUNEL positivity (adjusted $R 2 =0.39$, $p=0.02$). Preoperative treatment duration was positively correlated with TUNEL and caspase-3 immunopositivity ($r=0.526$, $p=0.02$; $r=0.475$, $p=0.04$, respectively) and negatively correlated with survivin immunopositivity ($r=-0.533$, $p=0.01$). Conclusions: Somatostatin analog treatment might induce apoptosis, increase autophagy, and decrease cell proliferation in GH-secreting adenomas. Also, proteins related to cross-talk between autophagy and apoptosis are upregulated after SRL treatment.

38. Mammillothalamic and Mammillotegmental Tracts as New Targets for Dementia and Epilepsy Treatment Balak, N., Balkuv, E., Karadag, A., (...), Erkan, B., Tanriover, N. 2018 World Neurosurgery 110, pp. 133-144

Background Recently, neuromodulation through deep brain stimulation (DBS) has appeared as a new surgical procedure in the treatment of some types of dementia and epilepsy. The mammillothalamic and mammillotegmental tracts are involved among the new targets. To our knowledge, a review article focused specifically on these mammillary body efferents is lacking in the medical literature. Their contribution to memory is, regrettably, often overlooked. Methods A review of the relevant literature was conducted. Results There is evidence that mammillary bodies can contribute to memory independently from hippocampal formation, but the mechanism is not yet known. Recent studies in animals have provided evidence for the specific roles of these mammillary body efferents in regulating memory independently. In animal studies, it has been shown that the disruption of the mammillothalamic tract inhibits seizures and that electrical stimulation of the mammillary body or mammillothalamic tract raises the seizure threshold. In humans, DBS targeting the mammillary body through the mammillothalamic tract or the stimulation of the anterior thalamic nucleus, especially in the areas closely related to the mammillothalamic tract, has been found effective in patients with medically refractory epilepsy. Nonetheless, little knowledge exists on the functional anatomy of the mammillary body efferents, and their role in the exact mechanism of epileptogenic activity and in the memory function of the human brain. Conclusions A comprehensive knowledge of the white matter anatomy of the mammillothalamic and mammillotegmental tracts is crucial since they have emerged as new DBS targets in the treatment of various disorders including dementia and epilepsy.

39. Cavernous sinus and parasellar region: An endoscopic endonasal anatomic cadaver dissection Erdogan, U., Turhal, G., Kaya, I., (...), Gode, S., Karci, B. 2018 Journal of Craniofacial Surgery 29(7), pp. e667-e670

The aim of this study was to investigate the neurovascular structures of the cavernous sinus with the endonasal endoscopic transpterygoid approach on fresh human cadavers. Additionally, the course of internal carotid artery (ICA) and relevant anatomy was thoroughly investigated to refine the anatomical landmarks, exposure difficulties, potential complications, and limitations using the endonasal endoscopic technique. This study was carried out at an otolaryngology department of a tertiary medical center between June 2014 and June 2015. The surgical dissection was performed on 10 fresh human cadaver specimens using paranasal sinus and skull base endoscopic instruments. Cavernous sinuses and parasellar area were explored via an endoscopic endonasal transpterygoid approach. Dehiscence was present in 5 (25%) cavernous ICAs. Projection of the cavernous ICA on the whole lateral sphenoid wall was prominent in 6 (%30) sphenoid sinuses. Anterior curve was prominent in 12 (60%) cavernous ICAs, whereas posterior was prominent in 7 (35%). Mean distance between the lateral wall of eustachian tube orifice and petrous ICA was 19.50±1.05 mm (range 18–22 mm). Cranial nerves of the cavernous sinus showed no variation. Control of the ICA is critical during the endonasal endoscopic approach to the cavernous sinus and skull base. The vidian nerve is a reliable and important landmark to the petrous ICA in the transpterygoid approach. Dissection of the eustachian tube and its relation to the ICA has to be kept in mind during nasopharyngeal surgery.

40. Double nasoseptal flap technique for endonasal pituitary surgery Gode, S., Biceroglu, H., Turhal, G., (...), Midilli, R., Karci, B. 2017 European Archives of Oto Rhino Laryngology 274(2), pp. 897-900

Endoscopic endonasal approach has been successfully used for the management of pituitary tumors; however, the loss of septal mucosa especially around sphenoethmoidal recess and posterior nasal septum might be a disadvantage of this technique. The aim of this study is to describe a variation of the endonasal approach, “double nasoseptal flap” technique in endoscopic transsphenoidal pituitary surgery, and to evaluate its outcomes. The technique depends on fully harvested bigger nasoseptal flap on one side and smaller on the other. Thirty patients were included. Functional results were assessed by preoperative and postoperative first month visual analogue scale (VAS), and morphology was evaluated by achieving intact septum from the sphenoid ostium to the columella. Sphenoid sinusitis, the presence of synechia and crusting in the sphenoethmoidal recess was also assessed. Mean VAS was 71 and 67 mm preoperatively and postoperatively, respectively ($p > 0.01$). There were no septal perforations, synechia, and sphenoid sinusitis postoperatively. Three patients had (10 %) crusts on sphenoethmoidal recess on first month postoperatively. Double nasoseptal flap technique has advantages, such as wider exposure during surgery; prepared flaps could be used if needed, better morphological and functional outcomes postoperatively. The technique is safe without any perforations and minimal crusting.

41. Osteointegration of a bisphenol-a-glycidyl-dimethacrylate composite and its use in anterior skull base defects: An experimental study in an experimental design model of cerebrospinal fluid leak Sanus, G.Z., Kucukyuruk, B., Biceroglu, H., (...), Kurkcu, M., Oz, B. 2014 Journal of Craniofacial Surgery 25(4), pp. 1524-1528

OBJECT: Promising clinical results were reported in watertight closure of anterior skull base defects (ASBDs) with bisphenol-a-glycidyl-dimethacrylate (bis-GMA)-based materials to prevent the cerebrospinal fluid leaks. However, interrelation of these materials with surrounding bones in histologic level, referred to as the osteointegration, has not been reported in the anterior skull base. In addition, an illustrative case with an ASBD that was repaired using a bis-GMA composite has been presented. METHODS: Twenty New Zealand rabbits were divided into 4 groups: control and sham groups consisted of 2 and 6 rabbits, respectively. The "skull base defect" group (n = 6) underwent a unifrontal craniectomy and an iatrogenic ASBD followed by creating a dural defect to obtain a cerebrospinal fluid leak. Similar bony and dural defects were acquired in the "repair with bis-GMA based allograft" group (n = 6), but the bony defect was closed with bis-GMA-based allograft. RESULTS: All animals in the "skull base defect" group died in 3 weeks after surgery. There were no animal losses in the "repair with bis-GMA based allograft" group at the sixth month. Histologic evaluation revealed complete osteointegration of bis-GMA composite with surrounding bones. CONCLUSIONS: bis-GMA based allograft achieved a watertight repair of the ASBD. Histologic findings of this study showed that bis-GMA composite is a reliable material to be used in the closure of anterior skull base bony defects.

42. Assessment of osteointegration of cortoss™ in cranioplasty: An experimental study in rabbits | [Kranioplastide cortoss™'un osteointegrasyonunun değerlendirilmesi: Tavşanlarda bir deneyselçalişma] Ulu, M.O., Sanus, G.Z., Ozlen, F., (...), Kurkcu, M., Tanriverdi, T. 2013 Journal of Neurological Sciences 30(1), pp. 144-152

Objectives: Calvarial defects must be closed for either cosmetic reasons or for protection of the calvarial contents. We aimed to assess whether Cortoss™, a biocompatible synthetic cortical bone void filler, can provide satisfactory osteointegration in cranial defects. Methods: Twenty New Zealand white adult rabbits were divided into 4 groups: craniectomy (n = 6), cranioplasty (n = 6), sham (n = 6) and control (n = 2) groups. Treatment for each group was as follows: craniectomy group had calvarial defects that were left empty; the cranioplasty group the defects were reconstructed with Cortoss™; the sham group had only a skin incision and no defect; and in the control group no surgery was performed. All the animals were sacrificed 6 months after the procedures and the materials were examined histopathologically and radiologically in order to assess osteointegration of Cortoss™. Results: Radiological examination demonstrated almost complete apposition of the bone to Cortoss™ without any defect or sutures and the cosmetic outcomes were satisfactory. Radiological findings were supported by the histopathologic examinations which revealed that osteointegration had been completed without any fibrous band formation surrounding the Cortoss™ implant. Conclusion: Cortoss™ leads to significant osteointegration at 24 weeks in rabbit calvarial defects. The results of this in vivo study suggest that Cortoss™ may be considered a safe and effective material for the reconstruction of calvarial defects.

43. Direct venous spinal reabsorption of cerebrospinal fluid: A new concept with serial magnetic resonance cisternography in rabbits - Laboratory investigation Biceroglu, H., Albayram, S., Ogullar, S., (...), Yildiz, C., Kiris, A. 2012 Journal of Neurosurgery Spine 16(4), pp. 394-401

Object. For nearly 100 years it has been believed that the main reabsorption of CSF occurs in arachnoid projections into the superior sagittal sinus, but a significant number of experiments and cases conflict with this hypothesis. According to recently published studies, CSF is permanently produced and absorbed in the whole CSF system. Clusters of arachnoidal villi, which are speculated to have a role in the reabsorption of CSF, have recently been revealed in the dorsal root of the spinal nerves. Huge absorptive surface areas of microvessels have been suggested to serve a putative role in reabsorption. The authors' aim was to observe direct venous connections between the subarachnoid space and the perispinal veins. Methods. Eleven adult (6 months old) New Zealand white male rabbits weighing approximately 3.0 kg each were used in this experiment. After obtaining precontrast MR cisternography images, subarachnoid access was gained percutaneously via a cisternal approach by using a 20-gauge intravenous indwelling cannula. One rabbit died as a result of brainstem trauma during percutaneous cannulation before contrast administration, but contrast agent was still injected to see the possible MR imaging results of spinal CSF reabsorption after death. Magnetic resonance imaging was performed at 15, 60, 120, and 180 minutes after the administration of contrast agent. After intramuscular injections of anesthetic, 2 rabbits died 120 and 150 minutes after contrast injection, but the MR imaging study at 180 minutes after contrast injection was still performed. Results. Direct connections between the subarachnoid space and the perispinal veins were observed in all rabbits during serial MR cisternography. The enhancement power was not affected by the amount of injected contrast agent or by cervical or lumbar penetration but was increased at higher contrast concentrations or upon seizure (physical activity). Conclusions. Extracranial reabsorption of CSF has been finally proved with direct radiological confirmation of spinal venous reabsorption of CSF using serial MR cisternography. The authors believe that this study can help to develop a more accurate model of CSF dynamics, which will allow understanding of many CSF-related diseases, as well as the development of new strategies for treatment.

44. Pregnancy-associated plasma protein A and high-sensitivitive C-reactive protein levels in chronic subdural haematoma patients | [Kronik subdural hematomlu hastalarda gebelik ilişkili plazma proteini-A ve yüksek duyarlı C-reaktif protein düzeyleri]Hanimoğlu, H., Ulu, M.O., Biçeroglu, H., (...), Elmaci, I., Uzan, M. 2011 Journal of Neurological Sciences 28(3), pp. 330-336

Objective: Pregnancy-associated plasma protein A (PAPP-A), a metalloproteinase that regulates insulinlike growth factor-1 bioavailability in vitro, has been suggested to play an active role in the pathophysiology of several conditions involving inflammatory responses. We investigated the values of PAPP-A and high sensitive CRP (hsCRP) levels in chronic subdural haematoma (CSDH) patients and healthy controls. Methods: PAPP-A and hsCRP levels were studied in the serum and subdural haematoma fluid of 20 consecutive patients with CSDHs (M/F: 12/8; mean age of 56.7) and in the serum of age matched 16 volunteers (M / F: 10 / 6; mean age: 54,2). Results: The serum PAPP-A [4.15 ng/mL (2.70-12.88)] levels of patients were significantly lower than control group [9.32 ng/mL (6.57 - 17.00)] ($p<0.01$) and the hsCRP levels were significantly higher in patient group [4.57 mg/L (1.56 -12.62)] ($p<0.01$). The comparison of PAPP-A values in the serum and subdural haematoma in the patient group revealed significantly very high values in the subdural fluid [204.5 ng/mL (161.1 - 261.4)] than the serum [4.15 ng/mL (2.70-12.88)] ($p<0.0001$). The hsCRP values, on the other hand, were significantly lower in the subdural haematoma fluid than the serum in the patient group ($p = 0.016$). Conclusion: PAPP-A may have an important function in the local inflammatory events and local structural

changes associated with CSDH formation and growth. The detection of high peripheral hsCRP levels in the patient group suggests that a systemic inflammatory response follows after the traumatic insult leading to CSDH formation.

45. Paraspinal gossybipoma: A case report and review of the literature Kucukyuruk, B., Biceroglu, H., Abuzayed, B., Ulu, M., Kafadar, A. 2010 Journal of Neurosciences in Rural Practice 1(2), pp. 102-104

Spinal or paraspinal retained surgical sponges (gossybipoma or textiloma) are rare incidents and mostly asymptomatic in chronic cases, but can be confused with other masses such as a hematoma, an abscess or a tumor. In chronic cases, the presentation can be as late as decades after the initial surgery; however, some gossybipomas cause infection or abscess formation in the early stages. The authors report a 40-year-old woman with a history of operation for lumbar disk herniation before 8 months, and got admitted with a complaint of serous fluid leakage from the operation wound. In this report, the authors discuss the clinical presentation, the radiologic findings and the differential diagnosis of gossybipoma.

46. Giant cell tumor of the frontal bone in an 18-month-old girl: A case report Ulu, M.O., Biceroglu, H., Ozlen, F., Oz, B., Gazioglu, N. 2010 Zentralblatt Fur Neurochirurgie 71(2), pp. 104-107

Introduction: Giant cell tumors (GCT) are benign, but locally aggressive primary bone neoplasms, that frequently occur in the epiphyses of the long bones. Less than 1% of all GCTs primarily involve the skull where they are preferentially seen in the sphenoid and temporal bones. In the pediatric age group they are exceptionally rare. Case Report: The authors report the management of a GCT involving the frontal bone in an 18-month-old girl. The patient underwent wide surgical excision of the lesion and remains free of clinical and radiological evidence of tumoral recurrence thirty months after treatment. Conclusion: Although rare, GCTs should be taken into consideration as a differential diagnosis of rapidly enlarging cranial mass lesions in pediatric patients. Gross total surgical excision eliminates the potential risks of adjuvant radiotherapy. However, considering the aggressive nature and potential malignancy of these lesions, careful long-term clinical and imaging follow-up is recommended.

47. The expression of astroglial glutamate transporters in patients with focal cortical dysplasia: An immunohistochemical study Ulu, M.O., Tanriverdi, T., Oz, B., (...), Ozyurt, E., Uzan, M. 2010 Acta Neurochirurgica 152(5), pp. 845-853

Purpose An abnormal increase in the extracellular glutamate is thought to play a crucial role in the initiation, spread, and maintenance of seizure activity. In normal conditions, the majority of this excess glutamate is cleared via glial glutamate transporters (EAAT-1 and EAAT-2). We aimed to examine the immunohistochemical expression of these transporters in the dysplastic tissues of patients with focal cortical dysplasia (FCD). Methods The parafin-embedded dysplastic tissues of 33 patients who were operated on due to medically intractable epilepsy and histopathologically diagnosed with FCD between 2001 and 2006 were stained immunohistochemically with appropriate antibodies, and the distribution and intensity of immunoreactivity (IR) of EAAT-1 and EAAT-2 were examined. The findings were compared with the histologically normal tissues of five patients who underwent temporal lobectomy for epilepsy surgery and 10 fresh postmortem cases. Results In the majority of the patients, the EAAT-1 and EAAT-2 IR were decreased, their astrocytic expression were lower, and the pattern of distribution were more diffused when compared to the control groups. Analyzing these findings according to the types of FCD revealed that as the severity of the dysplasia increased, the IR and astrocytic expression of both transporters are decreased and their distribution tend to be more "diffused". Conclusion The results of this study suggest a relationship between the decreased glutamate transporter expressions in dysplastic tissues which, in turn, may cause increased extracellular concentrations of glutamate and FCD pathophysiology. Further studies with larger patient populations, investigating the expression of glutamate transporters at mRNA and protein levels, are required to clarify their roles in the pathophysiology of FCD.

48. Intraosseous meningioma: A rare tumor reconstructed with porous polyethylene Kucukyuruk, B., Biceroglu, H., Abuzayed, B., Ulu, M.O., Sanus, G.Z. 2010 Journal of Craniofacial Surgery 21(3), pp. 936-939

A 45-year-old woman described the pain and the swelling at the left frontoparietal region. No significant findings were noted on physical examination, except a heterogeneous palpable lesion at the described region. Computed tomographic scan revealed an expansive bone lesion with homogeneous density, whereas magnetic resonance imaging revealed similar findings with no contrast enhancement. The lesion was totally resected, and cranioplasty with a porous polyethylene sheet (Medpor Biomaterial; Porex Surgical, Newnan, GA) was achieved. Histopathologic examination revealed an intraosseous meningioma. As far as we know, this case is the first case, in which total excision of the interosseous meningioma is followed by reconstruction with Medpor. Copyright © 2010 by Mutaz B. Habal, MD.

49. Endoscopic endonasal anatomy and approaches to the anterior skull base: A neurosurgeon's viewpoint Abuzayed, B., Tanriover, N., Gazioglu, N., (...), Eraslan, B.S., Akar, Z. 2010 Journal of Craniofacial Surgery 21(2), pp. 529-537

OBJECTIVES: The objective of this study was to review the endoscopic anatomy of the anterior skull base, defining the pitfalls of endoscopic endonasal approaches to this region. Recently, these approaches are gaining popularity among neurosurgeons, and the details of the endoscopic anatomy and approaches are highlighted from the neurosurgeons' point of view, correlated with demonstrative cases. MATERIALS AND METHODS: Twelve fresh adult cadavers were studied (n = 12). We used Karl Storz 0 and 30 degrees, 4 mm, 18- and 30-cm rod lens rigid endoscope in our dissections. After preparation of the cadaveric specimens, we approached the anterior skull base by the extended endoscopic endonasal approach. RESULTS: After resection of the superior portion of the nasal septum, bilateral middle and superior turbinates, and bilateral anterior and posterior ethmoidal cells, we could obtain full exposure of the anterior skull base. The distance between optic canal and the posterior ethmoidal artery ranged from 8 to 16 mm (mean, 11.08 mm), and the distance between posterior ethmoidal artery and the anterior ethmoidal artery ranged from 10 to 17 mm (mean, 13 mm). After resecting the anterior skull base bony structure and the dura between the 2 medial orbital walls, we could visualize the olfactory nerves, interhemispheric sulcus, and gyri recti. With dissecting the interhemispheric sulcus, we could expose the first (A1) and second (A2) segments of the anterior cerebral artery, anterior communicating artery, and Heubner arteries. CONCLUSIONS: This study showed that extended endoscopic endonasal approaches are sufficient in providing wide exposure of the bony structures, and the extradural and intradural components of the anterior skull base and the neighboring structures providing more controlled manipulation of pathologic lesions. These approaches need specific skill and learning curve to achieve more minimally invasive interventions and less postoperative complications. Copyright © 2010 by Mutaz B. Habal.

50. Endoscopic management of posterior fossa arachnoid cyst in an adult: Case report and Technical note | [Eriflkinde posterior fossa araknoid kistin endoskopik Tedavisi: Olgu Sunumu ve Cerrahi Teknik] Gazioglu, N., Kafadar, A.M., Tanriover, N., (...), Biceroglu, H., Ciplak, N. 2010 Turkish Neurosurgery 20(4), pp. 512-518

The authors report a case of large arachnoid cysts of the posterior fossa treated by endoscopic surgery. A 40-year-old man was admitted with a 3-month history of headache and progressive gait imbalance, with no significant medical history. At the time of admission, neurological examination revealed no abnormalities except for tandem imbalance. Brain computerized tomography (CT) scan and magnetic resonance imaging (MRI) revealed a posterior fossa arachnoid cyst (PFAC) causing brain stem compression accompanied by hydrocephalus. The patient was treated by endoscopic fenestration of the cyst with a paramedian suboccipital transcortical approach. Postoperatively the patient's complaints showed improvement and he was discharged with no complications. Follow up MRI showed a decrease in the cyst's size and the hydrocephalus with decompression of the brain stem.

51. Pneumatization degree of the anterior clinoid process: A new classification Abuzayed, B., Tanriover, N., Biceroglu, H., (...), Albayram, S., Akar, Z. 2010 Neurosurgical Review 33(3), pp. 367-374

The objective of this study is to determine the incidence and degree of anterior clinoid process pneumatization, in addition highlighting to their clinical significance. Multidetector-row CT scans of the skull base were reviewed in 648 subjects between 2007 and 2008. The presence of pneumatized anterior clinoid process and its degree were studied and documented. These datas were istatistically analyzed. Pneumatization of the ACP was found in 62 of 648 patients (9.6%) including 32 (51.6%) men and 30 (48.4%) women. The age of these patients ranged from 21 to 82 years (mean, 41±15.7 years). Pneumatization of the ACP occurred only on the left side in 14 cases (22.6%), only on the right side in 11 cases (17.7%), and bilaterally in 37 patients (59.7%). ACP pneumatization Type I, in which less than 50% of the ACP is pneumatized, was found in 47 of 124 sides (38%), Type II, in which more than 50% but not totally pneumatized ACP, was found in 28 of 124 sides (22.6%), and Type III, in which the ACP is totally pneumatized, was found in 22 of 124 sides (17.7%). The incidence of Type I in the general population was 6.6%, Type II was 3.5%, and Type III was 2.5%. Radiologically recognizing the degree of ACP pneumatization is important in decreasing the incidence of surgical complications during anterior clinoidectomy. Proper intraoperative management can be undertaken with special attention to the new classification. © Springer-Verlag 2010.

52. Supratentorial high grade astroblastoma: Report of two cases and review of the literature | [Supratentoryal yüksek dereceli astroblastom: Iki olgu sunumu ve literatürün gözden geçirilmesi] Kemerdere, R., Dashti, R., Ulu, M.O., (...), Albayram, S., Erdinçler, P. 2009 Turkish Neurosurgery 19(2), pp. 149-152

Astroblastoma is a rare glial tumor with uncertain histopathological origin and unpredictable clinical behavior. In this report, the authors present two cases of high grade intracerebral astroblastomas. Both tumors occurred in children as supratentorial, well-circumscribed, peripheral masses. The lesions differed radigraphically; one contained a huge cystic component and heterogeneously enhancing mural nodule while the other appeared as a prominently contrastenhancing solid mass lesion. Both patients were treated with surgery and postoperative radiotherapy. They were followed-up long-term and no recurrence of the tumor was detected in either case. We also discussed the radiological and histological characteristics with prognostic features.

53. An experimental model of traumatic nasoethmoidal cerebrospinal fluid fistula Sanus, G.Z., Ozlen, F., Biceroglu, H., (...), Albayram, M.S., Kaynar, M.Y. 2008 Journal of Craniofacial Surgery 19(2), pp. 441-445

Cerebrospinal fluid fistula secondary to head trauma is a potentially dangerous problem and precise localization and radical treatment is mandatory. The diagnostic technique is either computed tomography cisternography or MR cisternography. For evaluating the safety of diagnostic modalities and efficacy of treatment especially in terms of surgery, animal studies demonstrating traumatic cerebrospinal fistula model are indispensable not only for neurosurgeons but also for neuroradiologists. The authors in this paper describe a traumatic cerebrospinal fistula in an animal model using rabbits. The cerebrospinal fluid leakage was demonstrated successfully in all eight rabbits and was verified by computed tomography cisternography. The results led us to conclude that rabbit model of traumatic cerebrospinal fluid fistula is safe and has low mortality and morbidity rates. Further studies including larger number of animals should be considered in order to verify safety more accurately. ©2008Muntaz B. Habal, MD.

54. A case report: A non-infantile desmoplastic astrocytoma | [Olgu sunumu: Infantil olmayan dezmoplastik astrositom] Ulu, M.O., Tanriöver, N., Biçeroğlu, H., Öz, B., Canbaz, B. 2008 Turkish Neurosurgery 18(1), pp. 42-46

Introduction and Case Description: Desmoplastic infantile astrocytomas (DIA) are rare intracranial tumors of infancy with distinctive clinical and radiological features. Despite their radiologically aggressive appearance they tend to follow a benign course with favorable prognosis even after subtotal resections. Non-infantile cases are rarely encountered with only four cases reported before. The authors present a non-infantile DIA in a 4 years old female patient and discuss the clinical features, diagnosis, treatment of this rare entity. Conclusion: Although accepted as a tumor of infancy, DIA can also be encountered in older patients. Careful diagnosis and differentiation of DIA cases with other tumors, particularly malignant astrocytomas is important since the therapeutic strategies may differ.

HAKEMLİ KONGRE / SEMPOZYUM BİLDİRİ KİTAPLARINDA YER ALAN YAYINLAR

1. **Polyhydroxyalkonoate-based Biomaterials Functionalisation with VEGF and NGF for enhanced Peripheral Nerve Regeneration : A Comprehensive İn vitro, İn Silico and İn vivo Analysis** D.H.Sal,C. Taylor, E.C. Buluz, J.Hinchliffe, S.M.D.Syed Mohammed, A. Fricker, K.D.Kılıc, B.Derkus, **H.Biceroglu**, F.Claeyssens. J.W.Haycock, I.Roy 34th Anneal Conference of the European Society for Biomaterials. Torino Italy September 7-11 2025
2. **Development and Evaluation of VEGF-Contained Polyhydroxyalkanoate (PHA) Scaffolds for enhanced Peripheral Nerve Regeneration: A Comprehensive in vitro ,ex ovoCAM and İn vivo Analyses.** Dila Hatun Sal, Caroline Taylor, Jonathan Hinchliffe, Syed Mohammed DanielSyed Mohammed, Anabelle Fricker, Kubilay Kılıç, Özde Şenol, Büşra Horoz, Burak Derkus, **Hüseyin Biçeroğlu**, John W.Haycock, İpsita Roy. 2nd Internatıonal Microscopy and Spectroscopy Congress 25-27 September 2025 Acıbadem Mehmet Ali Aydınlar Üniversitesi Ataşehir İstanbul
3. **Revision And Complication Rates In First-Time Ventriculoperitoneal Shunt Placement In Adults: A Single-Center, Retrospective Study.** European Association Of Neurosurgical Societies Annual Congress, Viyana, Avusturya, 2025. Poster Bildiri; Anıl Erol, Nevhis Akıntürk, Mustafa Serdar Bölük, Kadri Emre Çalışkan, **Hüseyin Biçeroğlu**, Erkin Özgiray, Mehmet Sedat Çağlı, Taşkın Yurtseven.
4. **A Case Of Carcinoma Metastasis Of Unknown Primary Mimicking Spondylodiscitis In An Hiv+ Patient.** European Association Of Neurosurgical Societies Sofia Congress, Sofya, Bulgaristan, 2024. Poster Bildiri; 4141315: 977–977. Yazarlar: Anıl Erol, Mustafa Serdar Bölük, Khassan Saidazimov, **Hüseyin Biçeroğlu**, Taşkın Yurtseven.
5. **Sylvian Yerleşim Gösteren Kavernöz Anjiom Olgu Sunumu Ve Literatür Taraması. Türk Nöroşirürji Derneği** 38. Bilimsel Kongresi, Antalya, Türkiye, 2025. Poster Bildiri; 35: 221–221. Yunus Emre Kara, Mustafa Serdar Bölük, Anıl Erol, Taşkın Yurtseven, **Hüseyin Biçeroğlu**.
6. **Rezidü Idh-Mutant Astrositom Olgusunda Embolizasyon Sonrası Totale Yakın Regresyonu: Olgu Sunumu.** Türk Nöroşirürji Derneği 38. Bilimsel Kongresi, Antalya, Türkiye, 2025. Poster Bildiri; 35: 195–195. Yunus Emre Kara, Mustafa Serdar Bölük, Anıl Erol, Bilal Bahadır Akbulut, Taşkın Yurtseven, **Hüseyin Biçeroğlu**.
7. **Artırılmış Gerçeklik Tabanlı Nöronavigasyon Sistemi Entegre Cerrahi Mikroskop Ile Yapılan Temporal Kas Koruyucu Cerrahi.** Türk Nöroşirürji Derneği 37. Bilimsel Kongresi, Antalya, Türkiye, 2024. Sözlü Sunum; 34: 175–175. Anıl Erol, Kadri Emre Çalışkan, Mustafa Serdar Bölük, Taşkın Yurtseven, **Hüseyin Biçeroğlu.**
8. **Hipofiz Adenomu Ile Karışan Persistan Trigeminal Arter Anevrizması Olgu Sunumu** Türk Nöroşirürji Derneği 37. Bilimsel Kongresi, Antalya, Türkiye, 2024. Sözlü Sunum; 34: 187–187. Anıl Erol, Celal Çınar, Mustafa Serdar Bölük, **Hüseyin Biçeroğlu**, Taşkın Yurtseven.
9. **6. Kraniyal Sinir Tutulumu Ile Saptanan Posterior Klinoidal Kondrosarkom Olgu Sunumu.** Türk Nöroşirürji Derneği 37. Bilimsel Kongresi, Antalya, Türkiye, 2024. Poster Bildiri; 34: 211–211. Mustafa Serdar Bölük, Anıl Erol, Taşkın Yurtseven, **Hüseyin Biçeroğlu**.
10. **Lakrimal Bezinin Pleomorfik Adenomu Olgu Sunumu.** Türk Nöroşirürji Derneği 37. Bilimsel Kongresi, Antalya, Türkiye, 2024. Poster Bildiri; 34: 213–213. Çağdaş Çağırgan, Anıl Erol, Mustafa Serdar Bölük, Taşkın Yurtseven, **Hüseyin Biçeroğlu**.
11. **Spontan İntraparankimal Kanama Ile Tanı Konulan Trombosit Depo Havuzu Hastalığı Olgu Sunumu.** Türk Nöroşirürji Derneği 37. Bilimsel Kongresi, Antalya, Türkiye, 2024. Poster Bildiri; 34: 255–255. Anıl Erol, Mustafa Serdar Bölük, Çağdaş Çağırgan, Taşkın Yurtseven, **Hüseyin Biçeroğlu**.
12. **Subdural Kanamaya Eşlik Eden Bruselloz Olgu Sunumu**. Türk Nöroşirürji Derneği 37. Bilimsel Kongresi, Antalya, Türkiye, 2024. Poster Bildiri; 34: 261–261. Mustafa Serdar Bölük, Anıl Erol, Bilal Bahadır Akbulut, Taşkın Yurtseven, **Hüseyin Biçeroğlu.**
13. **Kliniğimizde Orta Meningeal Arterin Embolize Edilmesiyle Tedavi Edilen Kronik Subdural Hematomların Sonuçları.** Türk Nöroşirürji Derneği 37. Bilimsel Kongresi, Antalya, Türkiye, 2024.

Poster Bildiri; 34: 264–265. Anıl Erol, Kadri Emre Çalışkan, Mustafa Serdar Bölük, Nevhis Akıntürk, Celal Çınar, Erkin Özgiray, **Hüseyin Biçeroğlu**, Taşkın Yurtseven, Mehmet Sedat Çağlı.

14. **Dördüncü Ventrikül İçi Koroid Pleksus Ependimomu Olgu Sunumu**. Türk Nöroşirürji Derneği 37. Bilimsel Kongresi, Antalya, Türkiye, 2024. Poster Bildiri; 34: 265–265. Khassan Saidazimov, Anıl Erol, Çağdaş Çağırgan, Mustafa Serdar Bölük, Taşkın Yurtseven, **Hüseyin Biçeroğlu**.
15. **Spontan Subaraknoid Kanama Ve Kısa-Uzun Dönem Atmosferik Basınç Değişiklikleri: İntrakraniyal Anevrizma Rüptürü Üzerine Etkileri**. Türk Nöroşirürji Derneği Nörovasküler Sempozyumu, Trabzon, Türkiye, 2024. Sözlü Sunum; s.1–1. Erkin Özgiray, Nevhis Akıntürk, Anıl Erol, Kadri Emre Çalışkan, **Hüseyin Biçeroğlu**, Mehmet Sedat Çağlı, Taşkın Yurtseven, Celal Çınar.
16. SS-034 [Nörotravma ve Yoğun Bakım] **Kronık Subdural Hematomlarda Keyhole Ve Burr Hole Boşaltım Teknığının Sonuçlarının Karşılaştırılması** Bilal Bahadır Akbulut, Mustafa Serdar Bölük, **Hüseyin Biçeroğlu**, Taşkın Yurtseven Türk Nöroşirürji Dergisi - Türk Nöroşirürji Derneği 37. Bilimsel Kongresi 2024 , Cilt 34 , Ek Sayı
17. SS-168 [Diğer] **Ventrıkülo-Perıtonal Şant Olgularında Dıstal Kateterın Subkutanöz Dokuya Mıgrasyonu; Ender Bır Komplıkasyon Ve Rısk Faktörleri** Erkin Özgiray, Nevhis Akıntürk, Elif Ezgi Çenberlitaş, Kadri Emre Çalışkan, Mehmet Sedat Çağlı, Serdar Bölük, **Hüseyin Biçeroğlu**, Taşkın Yurtseven Türk Nöroşirürji Dergisi - Türk Nöroşirürji Derneği 37. Bilimsel Kongresi2024 , Cilt 34 , Ek Sayı
18. 21st International Symposium on Elektromagnetic Fields in Mechatronics,Electonic Engineering , **Development of an implantable wirelesspower transfer system for spraque dawley rats.** Şener Mert, Morçimen Zehra Gül, Kutlu Fatma Nur, Akbulut Bilal Bahadır, Beşikci Hicran, Boztepe Mutlu, Şendemir Aylin, **Biçeroglu Huseyin**, Gürses Barış Oğuz. Pavia September 12-15,2023 Museum of Electrical Technology
19. SS-139 [Spinal ve Periferik Sinir Cerrahisi] **Cerrahi Girişim Yapılan Spinal Metastazlı Multiple Myelom Olgularında Uzun Dönem Takip Ve Sonuçları** Erkin Özgiray1, Nevhis Akıntürk1, Elif Ezgi Çenberlitaş1, Sedat Çağlı1, **Hüseyin Biçeroğlu**1, Taşkın Yurtseven1, Yeşim Ertan2, Mehmet Zileli1 Türk Nöroşirürji Dergisi - Türk Nöroşirürji Derneği 36. Bilimsel Kongresi2023 , Cilt 33 , Ek Sayı
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155. **Glioblastoma Multiforme hastalarında DNA hasarı ve toplam antioksidan kapasite arasındaki ilişkinin araştırılması** Hanımoğlu H., Ulu M. O. , **Biçeroğlu H.,** İşler C., Tüzgen S., Atükeren P., Kaçıra T., Tanrıverdi T., Sanus G. Z. , Gümüştaş M. K. Türk Nöroşirürji Derneği 21. Bilimsel Kongresi, Antalya, Türkiye, 20 - 24 Nisan 2007
156. **Suplementer Motor Alan Lezyonları ve Cerrahi Tedavisi** Uzan M., Özkara Ç., Ulu M. O. , Tanrıöver N**., Biçeroğlu H.,** Yeni N., Sanus G. Z. Türk Nöroşirürji Derneği 21. Bilimsel Kongresi, Antalya, Türkiye, 20 - 24 Nisan 2007
157. **Suprasellar Aracnoid Cysts** Kaçıra T., **Biçeroğlu H.,** Gazioğlu M. N. Society of Nervous System Surgery, 2nd Scientific Congress, İstanbul, Türkiye, 16 - 19 Kasım 2006
158. **Beyin Frontal Loba Uzanan Sementoossifiyan Fibrom Olgusu** Yaman B., Sezak M., **Biçeroğlu H.,** Doğanavşargil Yakut B., Öztop F. 18. Ulusal Patoloji Sempozyumu, Belek, Antalya, Türkiye, 7 - 11 Mayıs 2006

ÖDÜLLER

1. **Nisan 2015 Video Bildiri Üçüncülük Ödülü:** Transnazal Klivo-odontoidektomi. Sercan Göde, Hüseyin Biçeroğlu, Sedat Çağlı, Raşit Midilli, Bülent Karcı, 11. Türk Rinoloji Kongresi

2. **Eylül 2014 Yılın Bildirileri, En iyi 10 Bildiri:** Lomber Diskopatili Hastaların 5 Aşamalı Pumdac-G Algoritması, Lomber MR ve Spinal Mouse Ölçümleri: 4000 Hastanın 550 günlük Takibi, Konservatif Yaklaşımın Uzun Dönem Klinik ,Radyolojik Fonksiyonel ve Cerrahi Sonuçlarının Prediktif Değeri. Hüseyin Biçeroğlu, Derya Özer Kaya, Hacı Kaymaz, Şeyda Toprak Çelenay, Anıl Özüdoğru,Gülay Girgin Biçeroğlu, Fatih Durna, Murat Hancı, Türk Nöroşirurji Derneği Spinal Ve Periferik Sinir Cerrahisi Öğretim Ve Eğitim Grubu Omurga Ve Omurilik Tümörleri Sempozyumu

3. **Nisan 2013 En iyi 10 Bildiri , İkincilik Ödülü :** Konusma'nın Mikrocerrahi Anatomisi:MR rehberliginde 3DHDR teknigi ile yapilan beyin cekirdek ve ak madde diseksiyonlarinin fonsiyonel ve kognisyonel sonuclari Hüseyin Biçeroğlu , Albert Rhoton Takeshi Funaki Barış Küçükyürük Necmettin Tanrıöver Mustafa Uzan Halil Ak, Türk Nöroşirürji Derneği

4. **Eylül 2012 En iyi 10 Bildiri /Sözel Sunum 1:** Microsurgical Anatomy of Cognitive Neurosurgery . Biceroglu H, Rhoton AJ. Kucukyuruk B. Tanrıöver N. Uzan M .Ak H, Sinir Sistemi Cerrahisi Derneği

5. **Nisan 2009 'Yılın Bildirileri Yedincilik Ödülü''**/ Perimezensefalik, Parakiazmatik,İnterpedinküler ve Prepontin Sisternalara İnfra ve Suprakiazmatik Genişletilmiş Endoskopik Endonazal Yaklaşım. Abuzayed B, Tanrıöver N, Gazioglu N, Biçeroğlu H, Çetin G,Akar Z, Türk Nöroşirürji Derneği

SERTİFİKA, KURS VE EĞİTİMLER

- 2025 11th SNSS Annual Meeting with International participation .Ethico-legal aspects of Neurosurgery in the 21st Century: Challeges and Opportunities. Hotel Sheraton,Novi Sad, October 23-26 , 2025
- 2025 WFNS World Congress of Neurosurgery 1-5 December 2025 Dubai, UAE,
- 2025 Brain Day Congress 2-4 May 2025, University of Health Sciences School of Internatıonal Medicine&Neuromer , İstanbul
- 2025 Türk Nöroşirürji Derneği TURNOG Kış Sempozyumu 11-13 Aralık 2025 ,İzmir.
- 2025 Back to the Future Congress Memento Vivere. 3-4 Mayıs 205. Pine Bay Kuşadası Aydın.
- 2025 Türk Nöroşirürji Derneği Cerrahi Nöroanatomi Öğretim ve Eğitim Grubu Cerrahi Nöroanatomi Sempozyumu Kafa Kaidesi ve Cerrahi Yaklaşımlar 1-2 Şubat 2025 Ondokuz Mayıs Üniversitesi Atatürk Kongre ve Kültür Merkezi,Samsun
- 2025 Türk Nöroşirürji Derneği Nörovasküler Sempozyum . 4-7 Eylül 2025 Denizli Davetli Konuşmacı, Denizli, Türkiye
- 2025 10. Hipofiz Adenomlarının Tedavisinde Endoskopik Transfenoidal Cerrahi Kursu 20 Nisan 2025 Cerrahpaşa Tıp Fakültesi. İstanbul, Türkiye
- 2024 4th International Rhoton Society Meeting 5-7 November 2024 Grand Hyatt Taipei Hotel. Taipei Taiwan.
- 2024 TURNOG 2024 Sempozyumu Kocaeli 5-7 Aralık 2024, Kocaeli, Türkiye
- 2024 Türk Nöroşirürji Derneği Stereotaktik Fonksiyonel Ağrı Epilepsi Cerrahisi Öğretim ve Eğitim Grubu 1. Ağrı Cerrahisi ve Uygulamaları Kadavra Kursu 30 Kasım 2024 İzmir Tınaztepe Üniversitesi Anatomi ve Güvenli Cerrahi İçin Araştırmalar Merkezi
- 2024 9. İstanbul Hipofiz Sempozyumu ‘’Her Yönüyle Akromegali’’ 9. Hipofiz Adenomlarının Tedavisinde Endoskopik Transfenoidal Cerrahi Kursu Hipofiz Adenomlarının Tedavisinde Endoskopik Endonazal Kafa Tabanı Cerrahisi Kursu 3 Mayıs 2024 İstanbul Üniversitesi - Cerrahpaşa, Cerrahpaşa Tıp Fakültesi, Anatomi Laboratuarı,
- 2024 1st Congress of Yaşargil Microneurosurgery Academy. June 4-7 2024 Renaissance Polat İstanbul Hotel İstanbul.
- 2024 6.Kafa Tabanı Kongresi 16-18 Şubat 2024 Miracle İstanbul Asia Hotel
- 2024 Kranial Mikrocerrahi Temel Yaklaşımlar Sempozyumu, SSCD 1 Haziran 2024 İstanbul Üniversitesi Çapa Tıp Fakültesi Kemal Atay Amfisi. İstanbul, Türkiye
- 2024 1.Çukurova Nöroşirurji İlkbahar Sempozyumu Hüseyin Biçeroğlu 17 Mayıs 2024 Çukurova Üniversitesi Balcalı Yerleşkesi, Adana
- 2024 13th International Meningioma Society Meeting , Microsurgical and Endoscopic Anatomy and Approaches for Skull Base Meningiomas with Special Emphasis on Cerebral Venous System Pre-Meetıng Course. Dedicated to Prof. Dr. Albert Rhoton Jr. May 8-11th 2024 in Istanbul-Turkey
- 2024 Türk Nöroşirurji Derneği Stereotaktik Fonksiyonel Ağrı ve Epilepsi Cerrahisi Öğrenim ve Eğitim Grubu 30 Kasım 2024 Cumartesi “1. Ağrı Cerrahisi ve Uygulamaları Kadavra Kursu” İzmir Tınaztepe Üniversitesi ,İzmir
- 2024 Acıbadem Mehmet Ali Aydınlar Üniversitesi 4th Skullbase Approaches Course Hands on Cadaver Workshop. 2-3 March 2024
- 2023. 2nd Deep Brain Stimulation and Pain Interventions Cadaver Course in Istanbul, Turkiye on May 26 – 28 2023,
- 2023 Acıbadem Mehmet Ali Aydınlar Üniversitesi 3rd White Matter Dissection Course 9-10 December 2023
- 2023 Acıbadem Mehmet Ali Aydınlar Üniversitesi 3rd Annual Endoscopic Skull Base Cadaver Course, Acibadem University’s CASE Neuroanatomy Laboratory in Istanbul from October 14th to 15th, 2023
- 2023 . 100 years of Neurosurgery in Serbia - Centennial Anniversary .Serbian Neurosurgical Society 9th SNSS Annual Meeting ,10th SNSS Congress with international participation. October 30th - November 3rd, 2023,
- 2023 Türk Nöroşirürji Derneği 36. Bilimsel Kongresi 27-30 Nisan 2023 Pine Beach Kongre Merkezi Belek Antalya Türkiye
- 2022. 35. Türk Nöroşirürji Derneği Bilimsel Kongresi, 16.Nöroşirürji Hemşireliği Kongresi 24-27 Kasım 2022 Antalya, Türkiye
- 2022 Türk Nöroradyoloji Diploması 4.Dönem 3.Kurs Anatomi,Embriyoloji ve Malformasyonlar. 15-17 Nisan 2022 ,Ege Palas Hotel İzmir.
- 2022. 7. İstanbul Hipofiz Sempozyumu Hipofiz Hastalarının Tedavisinde Endoskopik Endonazal Kafa Tabanı Cerrahisi Kursu İstanbul Üniversitesi - Cerrahpaşa, Cerrahpaşa Tıp Fakültesi, Nöroşirurji Anabilim Dalı, Cerrahi Nöroanatomi Laboratuarı 15 Nisan 2022
- 2020 Tıbbi Uygulama Hatalarında Temel Bilirkişilik Eğitimi (Uzaktan Eğitim), Acıbadem Mehmet Ali Aydınlar Üniversitesi
- 2020 Eğiticilerin Eğitimi Sertifika Programı (Uzaktan Eğitim), İstanbul Üniversitesi - Sürekli Eğitim Uygulama ve Araştırma Merkezi
- 2020. 5. Hipofiz Adenomlarının Tedavisinde Endoskopik Endonazal Kafa Tabanı Cerrahisi Kursu ve 3. Hipofiz Hastalıklarında Hemşirelik Bakımı Kursu, İstanbul Üniversitesi Cerrahpaşa
- 2020. 2. Kafatabanı Kadavra Kursu, Acıbadem Mehmet Ali Aydınlar Üniversitesi 8-9 Şubat 2020 (İstanbul)

- 2019 15. Sinir Sistemi Cerrahisi Kongresi, Sinir Sistemi Cerrrahisi Derneği (Edirne)
- 2019 NOVA 2019 Sempozyumu. ‘’Hassas Yerleşimli Lezyonlar”. 21-22 Aralık 2019 Acıbadem Üniversitesi Kerem Aydınlar Kampüsü,İstanbul
- 2019 4th Clinical Neuroscience Course " Current state and future in deep brain stimulation in Parkinsons disease", Ondokuz Mayıs Üniversitesi (Samsun)
- 2019 Binesymposium Neurovascular Conference: Bosphorus International Neuroscience Symposium, Acıbadem Maslak Hospital
- 4th Clinical Neuroscience Course ‘’Current Stae and future in Deep Brain Stimulation in Parkison’s Disease’’17-19 October 2019 Anemon Hotel,Samsun,Turkey
- 2019 1. Beyin Ak Madde Diseksiyon Kursu, Acıbadem Mehmet Ali Aydınlar Üniversitesi (İstanbul)
- 2019 1. Endoskopik Kafa Tabanı Kadavra Kursu, Acıbadem Mehmet Ali Aydınlar Üniversitesi 25-26 Mayıs 2019 (İstanbul)
- 2019 33. Türk Nöroşirürji Derneği Kongresi , Türk Nöroşirürji Derneği Antalya
- 2018 Kafa Tabanı Kadavra Kursu, Acıbadem Mehmet Ali Aydınlar Üniversitesi
- 2018 International Endoscopic Skull Base Surgery-Huanhu Symposium, 7th International Microneurosurgical Anatomy Symposium, 1st Rhoton Society Meeting .29th June -1st July 20182018 Tianjin ,China, Davetli Konuşmacı, Tianjin, Çin
- 2018 Neurosurgery Course Series-7 Masters in İstanbul, Prof.Dr. Evandro de Oliveria skull Base Course, Bahçeşehir Üniversitesi
- 2018 3. Kafa Tabanı Kongresi, Kafa Tabanı Cerrahisi Derneği
- 2018 NOVA Sempozyumu Orta Hat ve Ventriküliçi Yerleşimli Lezyonlar 23-25 Kasım 2018 Bahçeşehir Üniversitesi Beşiktaş Güney Kampüsü
- 2017 Vestibüler Schwannom ve İnfratentoryal Vasküler Lezyonlar NOVA Sempozyumu, Türk Nöroşirürji Derneği
- 2017 World Federation of Neurosurgical Societies 16.World Congress of Neurosurgery. August 20-25 2017 Istanbul Congress Center Turkey.
- 2017 North American Skull Base Society 27th Annual Meeting ,North American Skull Base Society New Orleans , LA2017
- 2017 İntrakranial Anevrizmalar ve Vasküler Nöroanatomi, Türk Nöroşirürji Derneği Cerrahi Nöroanatomi ve Nörovasküler Öğretim ve Eğitim Grupları (Mersin Üniversitesi)
- 2016 30. Türk Nöroşirürji Derneği Kongresi , Türk Nöroşirürji Derneği 8-12 Nisan 2016
- 2016 International Basic Neurosurgery Course Term 2 Course 1 " Neurotrauma and Functional Neurosurgery ", , Türk Nöroşirürji Derneği (Antalya)
- 2015 6th International Symposium on Microsurgical Anatomy , Bahçeşehir Üniversitesi Tıp Fakültesi
- 2015 6th International Symposium on Microsurgical Anatomy Pre-Meeting Cadaver Course, Bahcesehir University
- 2015 60. Yıl Onuruna Ege Üniversitesi Beyin Fonksiyonel ve Kognitif Mikrocerrahi Anatomisi Sempozyumu, Ege Üniversitesi Beyin ve Sinir Cerrahisi Anabilim Dalı
- 2015 29. Türk Nöroşirürji Derneği Kongresi . Türk Nöroşirürji Derneği (Antalya)
- 2015 International Basic Neurosurgery Course " Neurovascular Surgery " , Türk Nöroşirürji Derneği April 14-17 2015 Antalya
- 2015 60. Yıl Onuruna Ege Üniversitesi 1. Endoskopik Kafatabanı Cerrahisi Sempozyumu, Ege Üniversitesi Beyin ve Sinir Cerrahisi Anabilim Dalı
- 2015 International DBS Surgery & Microelectrode Recording Cadaver Course, Bahçeşehir Üniversitesi
- 2015 İntrinsik Beyin Lezyonları için Ak Madde Yollarının Üç Boyutlu Mikroanatomisi ve Cerrahisi , Türk Nöroşirürji Derneği Cerrahi Nöroanatomi Eğitim ve Öğretim Grubu (Ankara Üniversitesi)
- 2014 Hacettepe 3. Endoskopik Kafatabanı Cerrahisi Kursu 12-13 Aralık 2014, Hacettepe Üniversitesi
- 2014 Türk Nöroşirürji Derneği Nöroonkolojik Cerrahi Öğretim ve Eğitim Grubu Sempozyumu , 6-7 Aralık 2014 Türk Nöroşirürji Derneği .Barbaros Point Hotel / İstanbul
- 2014 Temel Moleküler Nöroonkoloji Kursu, Türk Nöroşirürji Derneği TURNOG (İstanbul)
- 2014 İleri Endoskopik Kafa Kaidesi ve Hipofiz Cerrahisi Kadavra Kursu , Kocaeli Üniversitesi
- 2014 Spinal ve Periferik Sinir Cerrahisi Öğretim ve Eğitim Grubu Omurga ve Omurilik Tümörleri Sempozyumu, Türk Nöroşirürji Derneği
- 2014 Türk Nöroşirürji Derneği 28. Bilimsel kongresi 4-8 Nisan 2014 Rixos Sungate Hotel& Kongre Merkezi ,Beldibi Antalya
- 2014 Skull Base Surgery Cadaver Course : Hands on Cadaveric Workshop, Bahçeşehir Üniversitesi Tıp Fakültesi Beyin ve Sinir Cerrahisi Anabilim Dalı ,İstanbul
- 2014 1 st ASNO Skull Base Anatomy Course : Hands-on Cadaveric Workshop , Asian Society for Neuro-Oncology (Bahçeşehir Üniversitesi, İstanbul)
- 2014 Kafatabanı Cerrahisi Kursu Prof.Rhoton Anatomy Labaratory Resmi Açılışı 30-Mayıs-01 Haziran BAU Faculty of Medicine Göztepe
- 2014 28. Türk Nöroşirürji Derneği Kongresi , 28. Türk Nöroşirürji Derneği Kongresi
- 2014 Lumbosakral Bölgede Girişimsel Ağrı Uygulamaları , Türk Nöroşirürji Derneği Spinal ve Periferik Sinir Cerrahisi Grubu
- 2013 10. Prof.Dr.Feyyaz Berkay Günleri Frontotemporal Bölge ve İnsular Lob Cerrahisi, İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi Beyin ve Sinir Cerrahisi Anabilim Dalı

- 2013 Kafa Tabanı Cerrahisi Kadavra Kursu , Marmara Üniversitesi Nörolojik Bilimler Enstitüsü
- 2013 TÜRK NÖROŞİRÜRJİ YETERLİK SERTİFİKASI, TÜRK NÖROŞİRÜRJİ DERNEĞİ
- 2013 27. Türk Nöroşirürji Derneği Kongresi , Türk Nöroşirürji Derneği
- 2012 3rd International Levantine Forum .''Advances in Neurological Surgery'' 15-18 November 2012 Sheraton Çeşme Hotel Çeşme/İzmir-Turkey
- 2012 A Celebration of the Art and Science of Teaching Neurosurgery recognizing Dr. Albert Rhoton's 40 years at the University of Florida, January 2012, Gainesville, Florida.
- 2012 SSCD 8. Bilimsel Kongresi , Sinir Sistemi Cerrahisi Derneği
- 2012 Beyin Fonksiyonel Organizasyonu ve Bağlantı Yolları Kursu, Yeditepe Üniversitesi
- 2012 4th International Symposium of Clinical Applied Anatomy (ISCAA), Türk Anatomi ve Klinik Anatomi Derneği (Ankara Üniversitesi)
- 2012 14. Ulusal Anatomi Kongresi,4th ISCAA International Symposium of Clinical and Applied Anatomy. Türk Anatomi ve Klinik Anatomi Derneği June28-July 01 2012
- 2012 26. Türk Nöroşirürji Derneği Kongresi , Türk Nöroşirürji Derneği
- 2011 Türk Nöroşirürji Derneği Cerrahi Nöroanatomi Öğretim ve Eğitim Grubu 2011 Kursu, Kafatabanı ve Bazal Sisternaların Endoskopik Cerrahisi Anatomisi, , Ankara Üniversitesi ,Ankara Tıp Fakültesi, Anatomi Anabilim Dalı
- 2011 Microsurgical Approaches to the Brain, Ventricles, and Skull Base, Depatment of Neurological Surgery, University of Florida McKnight Brain Institute Gainesville Florida
- 2011 Florida Senior Resident Skull Base Course, University of Florida
- 2011 79th AANS Annual Meeting , American Association of Neurological Surgeons
- 2011 Approaches to the Skull Base Workshop, University of Florida -Medtronic Midas Rex Institute , Forth Worth Texas
- 2010 Türk Nöroşirürji Derneği Cerrahi Nöroanatomi Öğretim ve Eğitim Grubu Kursu : Serebrovasküler By-pass Teknikleri ve Serebrum Ak Madde Yollarının Mikrocerrahi Anatomisi, Türk Nöroşirürji Derneği (Göztepe Eğitim ve Araştırma Hastanesi)
- 2010 İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi 7. Prof.Dr. Feyyaz Berkay Günleri , İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi Beyin ve Sinir Cerrahisi Anabilim Dalı
- 2010 Microsurgical Neuroanatomy (Post Doctoral Associate), The Department of Neurological Surgery , University of Florida Brain Institute Gainesville , Florida
- 2010 TOEFL, Yabancı Dil, ETS Listening, Learning, Leading
- 2009 2. Endoskopik Sellar Parasellar Bölge Cerrahisi Kursu , Hacettepe Tıp Fakültesi Beyin ve Sinir Cerrahisi Anabilim Dalı
- 2009 Türk Nöroşirürji Derneği Stereotaktik ,Fonksiyonel, Ağrı ve Epilepsi Cerrahisi Öğretim ve Eğitim Grubu Tremor ve Epilepsi konulu Sonbahar Sempozyumu, Türk Nöroşirürji Derneği (Ankara Gazi Üniversitesi Tıp Fakültesi)
- 2009 Cerrahpaşa Nöroloji Günleri 5 Olgularla Nöroloji , İstanbul Üniversitesi , Cerrahpaşa Tıp Fakültesi Nöroloji Anabilim Dalı
- 2009 Supra-İnfratentoriyal Bölge ve Ventriküllere Mikrocerrahi ve Endoskopik Yaklaşımlar Kursu Türk Nöroşirürkji Derneği Cerrahi Nöroanatomi Öğretim -Eğitim Grubu (İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi)
- 2009 23. Türk Nöroşirürji Derneği Kongresi , Türk Nöroşirürji Derneği
- 2008 Serebrovasküler Lezyonların Tedavisinde Mikro-Nöroşirürjikal ve Endovasküler Yöntemler Kursu, İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi Nöroşirürji Anabilim Dalı ve Nöroradyoloji Bilim Dalı
- 2008 2nd Course of Endoskopic Pituitary Surgery, Istanbul University Cerrahpasa Medical Faculty Depatment of Neurosurgery
- 2008 Türk Nöroşirürji Derneği Öğretim ve Eğitim Kurulu Araştırma Kurulu 3. Kurs : Etikten Araştırmaya Araştırmadan Yayına, Türk Nöroşirürji Derneği (Zonguldak Karaelmas Üniversitesi)
- 2008 22. Türk Nöroşirürji Derneği Kongresi , Türk Nöroşirürji Derneği
- 2007 1. Endoskopik Hipofiz Cerrahisi Kursu , Hacettepe Üniversitesi Tıp Fakültesi Nöroşirürji Anabilim Dalı
- 2007 21. Türk Nöroşirürji Derneği Kongresi , Türk Nöroşirürji Derneği
- 2007 Patolojik Omurga Kırıklarının Tedavisinde Vertebroplasti , Sinir Sistemi Cerrahisi Derneği (İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi)
- 2006 Deney Hayvanları Uyglama ve Etik Kursu, İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi
- 2006 4. Feyyaz Berkay Günleri: Microsurgery Course of İntrkranial Aneurysms, İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi
- 2005 3. Feyyaz Berkay Günleri : Endoskopik Hipofiz Cerrahisi , İstanbul Üniversitesi Cerrahpaşa Tıp Fakültesi Nöroşirürji Anabilim Dalı

DAVETLİ KONUŞMALAR

1. 2025 11th SNSS Annual Meeting with International participation .Ethico-legal aspects of Neurosurgery in the 21st Century: Challeges and Opportunities. **Posterior Approaches to Foramen Magnum.** Hüseyin Biçeroğlu Hotel Sheraton,Novi Sad, October 23-26 , 2025 Davetli Konuşmacı, Novi Sad , Sırbistan
2. 2025 WFNS World Congress of Neurosurgery **3D-HDR Stepwise 3T MRI navigated dissection of Diencephalic/Mesencephalic Fibers and Nuclei** Hüseyin Biçeroğlu . 1-5 December 2025 Dubai, UAE, Davetli Konuşmacı, Dubai Birleşik Arap Emirlikleri
3. 2025 WFNS World Congress of Neurosurgery **Neuroanatomical Pitfalls and Pearls Posterior Clinoidal Menenjiomas** Hüseyin Biçeroğlu . 1-5 December 2025 Dubai, UAE, Davetli Konuşmacı, Dubai Birleşik Arap Emirlikleri
4. 2025 WFNS World Congress of Neurosurgery **Premeeting Neuroanatomy Course-Updates on Endoscopy,Spine and Peripheral Nerve:Neuroanatomy and Surgical Techniques -Part 8 Chairmen** Hüseyin Biçeroğlu, di Russo Paolo . 1-5 December 2025 Dubai, UAE, Oturum Başkanı , Dubai Birleşik Arap Emirlikleri
5. 2025 Türk Nöroşirürji Derneği TURNOG Kış Sempozyumu **Serebellum Fonksiyonel Mikrocerrahi Anatomisi** Hüseyin Biçeroğlu 11-13 Aralık 2025 ,İzmir. Davetli Konuşmacı, İzmir, Türkiye
6. 2025 Türk Nöroşirürji Derneği Nörovasküler Sempozyum . **Spinal Kord Vaskülarizasyonu ve Cerrahi Nöroanatomisi** Hüseyin Biçeroğlu 4-7 Eylül 2025 Denizli Davetli Konuşmacı, Denizli, Türkiye
7. 2025 Türk Nöroşirürji Derneği Stereotaktik Fonksiyonel Ağrı ve Epilepsi Cerrahisi Öğretim ve Eğitim Grubu İlkbahar Sempozyumu **Spastisite ve Stereotaktik Biopside Zor Olgular** Hüseyin Biçeroğlu 13-16 Mart 2025 Paloma Perissia Otel Kongre Merkezi, Side/Antalya Davetli Konuşmacı, Antalya, Türkiye
8. 2025 Brain Day Congress **Microsurgical Neuroanatomical Pirinciples Of Human Glioma Pathways : Stepwise MRI Guided Dissection Of Human Brain Nuclei And Fibers** .Hüseyin Biçeroğlu 2-4 May 2025, University of Health Sciences School of Internatıonal Medicine&Neuromer
9. 2025 Back to the Future Congress Memento Vivere. **Beyin Cerrahisinde Geçmiş ve Gelecek Perspektifi .** Doç.Dr. Hüseyin Biçeroğlu 3-4 Mayıs 205. Pine Bay Kuşadası Aydın. Davetli Konuşmacı, Aydın, Türkiye
10. 2025 EMSA Ege Tıp Bilimi **Neşter ve Felsefe: Beyin Cerrahisinin İnce Sanatı** Doç. Dr. Hüseyin Biçeroğlu 6 Kasım 2025 Ege Üniversitesi Beyin ve Sinir Cerrahisi Anabilim Dalı Konferans Salonu Davetli Konuşmacı, İzmir, Türkiye
11. 2025 Türk Nöroşirürji Derneği Cerrahi Nöroanatomi Öğretim ve Eğitim Grubu Cerrahi Nöroanatomi Sempozyumu Kafa Kaidesi ve Cerrahi Yaklaşımlar **Anterior Kafa Tabanı Mikrocerrahi Nöroanatomisi** Dr. Hüseyin Biçeroğlu 1-2 Şubat 2025 Ondokuz Mayıs Üniversitesi Atatürk Kongre ve Kültür Merkezi,Samsun Davetli Konuşmacı, Samsun, Türkiye
12. 2025 ULUBTAT Cerrahi Yaklaşım Kongresi, **Beyin ve Sinir Cerrahisinde Geçmiş ve Gelecek Perspektifleri** Hüseyin Biçeroğlu . 7 Şubat 2025 İzmir. Davetli Konuşmacı, İzmir, Türkiye
13. 2025 ÜNİDES Ege'de Kariyer Günleri Konferansı. **Beyin Cerrahisi Felsefesi ve Süreci** Hüseyin Biçeroğlu 26 Nisan 2025 Ege Üniversitesi Hipokrat Amfisi İzmir. Davetli Konuşmacı, İzmir, Türkiye
14. 2025 The Comprehensive Neuroanatomy Educational Course: Module 2 Presented by the Yemeni Neurosurgical Society in collaboration with WFNS-YNS Forum, Pakistan Society of Neurosurgeons, Neurosurgery Coach, and Neurosurgical.TV. Date: Friday, February 7th 2025 4th Webinar Topic: **The Occipital Lobe Anatomy: Sulci, Gyri, and Functional Regions** Dr Huseyin Biceroglu. Davetli Konuşmacı, Uluslararası Online Webinar
15. 2025 European Association of Neurosurgical Societies EANS2025 Vienna Congress **Advancement in AI and robotics in neurosurgery (Trends & Innovation Morning Session)** Messe Wien Exhibition & Congress Center, between 5-9 October 2025. Faculty Chair, Vienna ,Austria
16. 2025 **Geçmişten Günümüze Ak Madde Yolları** Hüseyin Biçeroğlu Konferans 31 Ocak 2025 Dr.Lütfi Kırdar Kartal Şehir Hastanesi Kliniği,İstanbul. Davetli Konuşmacı, İstanbul, Türkiye

17. 2025 10. Hipofiz Adenomlarının Tedavisinde Endoskopik Transfenoidal Cerrahi Kursu **Endoskopik Endonazal Kafa Tabanı Cerrahisi: Çıkarılan Dersler ve Peroperatif Komplikasyonların Yönetimi** Osman Tanrıverdi, Hüseyin Biçeroğlu, Alperen Vural 20 Nisan 2025 Cerrahpaşa Tıp Fakültesi. Davetli Konuşmacı, İstanbul, Türkiye
18. 2024 13th International Meningioma Society Meeting , Microsurgical and Endoscopic Anatomy and Approaches for Skull Base Meningiomas with Special Emphasis on Cerebral Venous System Pre-Meetıng Course. Dedicated to Prof. Dr. Albert Rhoton Jr. May 8-11th 2024 in Istanbul-Turkey **Far-Lateral Approach and Its Paracondylar Modifications – 3D Presentation** Hüseyin Biçeroğlu 8th May 2024 Davetli Konuşmacı, İstanbul, Türkiye
19. 2024 4th International Rhoton Society Meeting **Stepwise MRI navigated dissection of diencephalic and mesencephalic nuclei**. Huseyin Biceroglu, Turkey 5-7 November 2024 Grand Hyatt Taipei Hotel. Taipei Taiwan. Davetli Konuşmacı, Taipei, Taiwan
20. 2024 1st Congress of Yaşargil Microneurosurgery Academy. **Stepwise 3D-HDR MRI Navigated Microsurgical Anatomy of Diencephalic and Mesencephalic Fibers and Nuclei.** June 4-7 2024 Renaissance Polat İstanbul Hotel İstanbul. Davetli Konuşmacı, İstanbul, Türkiye
21. 2024 13th International Meningioma Society Meeting **Pitfalls and Pearls of Endoscopy in Skull Base Meningiomas** Hüseyin Biçeroğlu May 8-11th in Istanbul-Turkey Davetli Konuşmacı, İstanbul, Türkiye
22. 2024 13th International Meningioma Society Meeting **Posterior Clinoidal Meningiomas** Hüseyin Biçeroğlu May 8-11th in Istanbul-Turkey Davetli Konuşmacı, İstanbul, Türkiye
23. 2024 TURNOG 2024 Sempozyumu Kocaeli Dr. Hüseyin Biçeroğlu **"Neler öğrendim? Nasıl yapıyorum?"** 5-7 Aralık 2024 Davetli Konuşmacı, Kocaeli, Türkiye
24. 2024 Kranial Mikrocerrahi Temel Yaklaşımlar Sempozyumu, SSCD **Posterior Petrosal (presigmoid) Yaklaşımın Mikrocerrahi Anatomisi** Hüseyin Biçeroğlu 1 Haziran 2024 İstanbul Üniversitesi Çapa Tıp Fakültesi Kemal Atay Amfisi. Davetli Konuşmacı, İstanbul, Türkiye
25. 2024 9. İstanbul Hipofiz Sempozyumu ''Her Yönüyle Akromegali'' 9. Hipofiz Adenomlarının Tedavisinde Endoskopik Transfenoidal Cerrahi Kursu Hipofiz Adenomlarının Tedavisinde Endoskopik Endonazal Kafa Tabanı Cerrahisi Kursu **Endoskopik Endonazal Kafa Tabanı Cerrahisi: Çıkarılan Dersler ve Peroperatif Komplikasyonların Yönetimi** Osman Tanrıverdi, Hüseyin Biçeroğlu İstanbul Üniversitesi - Cerrahpaşa, Cerrahpaşa Tıp Fakültesi, Anatomi Laboratuarı 3 Mayıs 2024, Cuma Davetli Konuşmacı, İstanbul, Türkiye
26. 2024 1. Çukurova Nöroşirurji İlkbahar Sempozyumu **Sellar Parasellar Tümör Cerrahisinde Nüanslar** Hüseyin Biçeroğlu 17 Mayıs 2024 Çukurova Üniversitesi Balcalı Yerleşkesi, Adana. Davetli Konuşmacı, Adana, Türkiye
27. 2024 Acıbadem Mehmet Ali Aydınlar Üniversitesi 4th Skullbase Approaches Course Hands on Cadaver Workshop. **Posterior Petrozal Yaklaşım** Hüseyin Biçeroğlu 2-3 March 2024 Davetli Konuşmacı, İstanbul, Türkiye
28. 2024 6.Kafa Tabanı **Kongresi Endoskopik Endonazal Supra: Infrakiazmatik Koridor İle 3. Ventriküle Yaklaşım** Hüseyin Biçeroğlu 16-18 Şubat 2024 Miracle İstanbul Asia Hotel Davetli Konuşmacı, İstanbul, Türkiye
29. 2024 ENMET by EMSA Ege NEXUS Webinarlar Serisi **"Nöroşirurjinin geleceği: geleceğin cerrahlarına tavsiyeler"** Doç. Dr. Hüseyin Biçeroğlu 28 Kasım 2024 Ulusal Online Webinar
30. 2024 İzmir Online Nöroşirürji ION **Yeni Başlayanlar İçin Endoskopik Kafa Kaide Cerrahisi** Doç. Dr. Hüseyin Biçeroğlu 26 Haziran 2024 Ulusal Online Webinar
31. 2023 8. İstanbul Hipofiz Sempozyumu **Prolaktinoma ve Hipofizit Paneli** Moderatörler: Nurdan Gül, Hüseyin Biçeroğlu Davetli Moderatör, İstanbul, Türkiye
32. 2023 **Geçmişten Günümüze Ak Madde Yolları** Hüseyin Biçeroğlu Konferans 6 Aralık 2023 Pamukkale Üniversitesi Beyin ve Sinir Cerrahisi Anabilim Dalı Konferans Salonu,Denizli Davetli Konuşmacı, Denizli, Türkiye
33. 2023 Acıbadem Mehmet Ali Aydınlar Üniversitesi 3rd White Matter Dissection Course**. Medial Surface Anatomy Medial to Lateral Dissection Technique** Hüseyin Biçeroğlu 9-10 December 2023 Davetli Konuşmacı, İstanbul, Türkiye
34. 2023 Acıbadem Mehmet Ali Aydınlar Üniversitesi 3rd Annual Endoscopic Skull Base Cadaver Course, **Endoscopic Transsphenoidal Supra and Infrachiasmatic Approaches for 3rd Ventricul**

Epidermoid Tumors. Hüseyin Biçeroğlu Acibadem University's CASE Neuroanatomy Laboratory in Istanbul from October 14th to 15th, 2023. Davetli Konuşmacı, İstanbul, Türkiye

35. 2023 Acıbadem Mehmet Ali Aydınlar Üniversitesi 4.Kafatabanı Kadavra Kursu **Posterior Petrozal Yaklaşım** Hüseyin Biçeroğlu 14-15 Ocak 2023 Davetli Konuşmacı, İstanbul, Türkiye
36. 2023 8. İstanbul Hipofiz Sempozyumu 8. Hipofiz Adenomlarının Tedavisinde Endoskopik Endonazal Kafa Tabanı Cerrahisi Kursu Hipofiz Adenomlarının Tedavisinde Endoskopik Endonazal Kafa Tabanı Cerrahisi Kursu . **Endoskopik Endonazal Kafa Tabanı Cerrahisi: Çıkarılan Dersler ve Peroperatif Komplikasyonların Yönetimi** Nurperi Gazioğlu, Necmettin Tanrıöver, Murat Geyik, Osman Tanrıverdi, Hüseyin Biçeroğlu İstanbul Üniversitesi - Cerrahpaşa, Cerrahpaşa Tıp Fakültesi, Anatomi Laboratuarı 14 Nisan 2023, Cuma Davetli Konuşmacı, İstanbul, Türkiye
37. 2023 8. İstanbul Hipofiz Sempozyumu **Prolaktinoma Paneli Oturum Başkanlığı** Hüseyin Biçeroğlu İstanbul Üniversitesi - Cerrahpaşa, Cerrahpaşa Tıp Fakültesi, 14-15 Nisan 2023, Oturum Başkanlığı, İstanbul, Türkiye
38. 2023 3rd Internatıonal Rhoton Socıety Meetıng August 22 - 24, 2023 Future Of Mıcroneurosurgery August 25, 2023 Y-Sıttıng Posıtıon In Neurosurgery August 26, 2023 **3D-Hdr Documented Stepwise Dissected Mr Navigated Microsurgical Anatomy Of Human Brain Nuclei And Fiber Systems** . Elite World Asia Hotel – Istanbul, Davetli Konuşmacı, İstanbul, Türkiye
39. 2023 3rd Internatıonal Rhoton Socıety Meetıng August 22 - 24, 2023 Future Of Mıcroneurosurgery August 25, 2023 Y-Sıttıng Posıtıon In Neurosurgery August 26, 2023 **Chairmen Andrew Grande Huseyin Biceroglu** . Elite World Asia Hotel – Istanbul, Oturum Başkanlığı, İstanbul, Türkiye
40. 2023 . 100 years of Neurosurgery in Serbia - Centennial Anniversary .Serbian Neurosurgical Society 9th SNSS Annual Meeting ,10th SNSS Congress with international participation. **MRI Navigation Guided 3D-HDR Human Dep Brain Nuclei: Stepwise Cadaveric Dissection.** Hüseyin Biçeroğlu October 30th - November 3rd, 2023, Davetli Konuşmacı, Belgrad, Sırbistan
41. 2023 Türk Nöroşirürji Derneği 36. Bilimsel Kongresi **Panel: Beynin Ön Dolalımının Mikrocerrahi Anatomisi Oturum Başkanları** Hüseyin Biçeroğlu Mert Şahinoğlu. 27-30 Nisan 2023 Pine Beach Kongre Merkezi Belek Antalya Oturum Başkanlığı Antalya, Türkiye
42. 2023 Yineleyen Glioblastomda Tedavi Atölyesi. **Yinelenmiş Glioblastomda Cerrahi Tedavi**. Hüseyin Biçeroğlu 13 Mayıs 2023. Ege Üniversitesi Tıp Fakültesi Radyasyon Onkolojisi Anabilim Dalı İzmir. Davetli Konuşmacı, İzmir, Türkiye
43. 2023 Türk Nöroradyoloji Akademisi. **Nöroradyoloji Bakış Açısıyla Endoskopik -Mikroskopik Kafa Kaidesi Nöroşirürjikal Anatomisi** Hüseyin Biçeroğlu 27 Mart 2023 . Ulusal Online Webinar
44. 2022 İzmir Tınaztepe Üniversitesi I. Endoskopik Kafa Tabanı Kadavra Kursu 23.04.2022 - 24.04.202 **Endoskopik Transtuberkulum/Transplanum Yaklaşım** Hüseyin Biçeroğlu Davetli Konuşmacı, İzmir, Türkiye
45. 2022 Türk Nöroradyoloji Diploması 4.Dönem 3.Kurs Anatomi,Embriyoloji ve Malformasyonlar. Hüseyin Biçeroğlu .**Derin Gri Maddenin Anatomi ve Fonksiyonu** 15-17 Nisan 2022 ,Ege Palas Hotel İzmir. Davetli Konuşmacı, İzmir, Türkiye
46. 2022. 7. İstanbul Hipofiz Sempozyumu Hipofiz Hastalarının Tedavisinde Endoskopik Endonazal Kafa Tabanı Cerrahisi Kursu İstanbul Üniversitesi - Cerrahpaşa, Cerrahpaşa Tıp Fakültesi, Nöroşirurji Anabilim Dalı, Cerrahi Nöroanatomi Laboratuarı 15 Nisan 2022, Cuma **Endoskopik Endonazal Kafa Tabanı Cerrahisi: Çıkarılan Dersler ve Peroperatif Komplikasyonların Yönetimi** Nurperi Gazioğlu, Necmettin Tanriöver, Osman Tanriverdi, Hüseyin Biçeroğlu Davetli Konuşmacı, İstanbul, Türkiye
47. 2022. 35. Türk Nöroşirürji Derneği Bilimsel Kongresi **Kafatabanı Endoskopik Yaklaşımların Mikrocerrahi Anatomisi** .24-27 Kasım 2022 Antalya Davetli Konuşmacı, Antalya, Türkiye
48. 2022. 35. Türk Nöroşirürji Derneği Bilimsel Kongresi, 16.Nöroşirürji Hemşireliği Kongresi Panel 6 **Perisilvian Konuşma Merkezleri Cerrahisi ve Bakım** Hüseyin Biçeroğlu. 24-27 Kasım 2022 Antalya Davetli Konuşmacı, Antalya, Türkiye
49. 2022 TND İzmir Toplantıları **"Yüzeyden Derine MR Navigasyon eşliğinde Beyin Mikrocerrahi Anatomisi"** Doç.Dr.Hüseyin Biçeroğlu 21 Ekim 2022 İzmir Medicana Hastanesi Konferans Salonu. Davetli Konuşmacı, İzmir, Türkiye
50. 2022 Fevziyeliler Işıklılar Derneği **Kariyer Günü Tıp.** Doç. Dr. Hüseyin Biçeroğlu 22 Nisan 2022 Ulusal Online Webinar

51. 2022 Neuro-Oncology Society Online Conference Series . **Tek Kadavrada Nöronavigasyon eşliğinde Perisilvian Bağlantı yolları ve Derin Beyin Cekirdek Anatomisi** .Hüseyin Biçeroğlu Neuro-Oncology Society Online Conference May 16th 2022. Ulusal Online Webinar
52. 2021 **MRI Navigated Stepwise Dissected 3D-HDR Documented Microsurgical Anatomy of Central Core** Hüseyin Biçeroğlu Seminer . Yeditepe Üniversitesi Beyin ve Sinir Cerrahisi Kliniği Nöroanatomi Laboratuvarı 16 Ekim 2021 Davetli Konuşmacı, İstanbul, Türkiye
53. 2021 Nöroradyoloji Akademisi **Tek Kadavrada Nöronavigasyon eşliğinde Perisilvian Bağlantı yolları ve Derin Beyin Cekirdek Anatomisi** .Hüseyin Biçeroğlu 17 Mayıs 2021 Turkish Neuroradiology Society Online Conference May 16th 2022. Ulusal Online Webinar
54. 2021 Acıbadem University II. White Matter Dissection Course and Surgery of Gliomas - Masters with Turkish Rhoton Fellows Group .**Navigation Guided HDR Brain Central Core Anatomy**. Hüseyin Biçeroğlu 7 May 2021 . Uluslararası Online Webinar
55. 2021 Acıbadem University II. Endoscopic Skull Base Course(Online) Masters with Turkish Rhoton Fellows Group. **Endoscopic Transtuberculum Approach and Infrachiasmatic Corridor Case Panel 20 Minutes** Hüseyin Biçeroğlu. 23 January 2021 Uluslararası Online Webinar
56. 2020 Acıbadem University III. Skull Base Course (Online) Topic: Online Skull Base Course - Masters with Turkish Rhoton Fellows **Posterior Petrosal Approach Online Cadaveric Dissection 60 Minutes** at Acıbadem University Hüseyin biçeroğlu 7,8,14 and 15th November 2020. Uluslararası Online Webinar
57. 2020. 5. İstanbul Hipofiz Sempozyumu: Hipofiz Adenomlarının Tedavisinde Endoskopik Endonazal Kafa Tabanı Cerrahisi Kursu 6 Mart 2020. **Endoskopik Endonazal Kafa Tabanı Cerrahisi: Çıkarılan Dersler Ve Peroperatif Komplikasyonların Yönetimi** Nurperi Gazioğlu Necmettin Tanrıöver Osman Tanrıverdi Hüseyin Biçeroğlu Davetli Konuşmacı, İstanbul, Türkiye
58. 2020. 5. İstanbul Hipofiz Sempozyumu 7 Mart 2020. **Endoskopik Endonazal Sinus Cerrahisinde Sino-Nazal Komplikasyonlar** Hüseyin Biçeroğlu Davetli Konuşmacı, İstanbul, Türkiye
59. 2020 Acıbadem Üniversitesi II. Kafa Tabanı Kadavra Kursu . **Posterior Petrozal Yaklaşım**,8-9 Şubat 2020 Davetli Konuşmacı, İstanbul, Türkiye
60. 2019 NOVA 2019 Sempozyumu. ‘’Hassas Yerleşimli Lezyonlar’’. **Mezial Temporal Bölgenin Nöral ve Vasküler Anatomisi** .Dr.Hüseyin Biçeroğlu. 21-22 Aralık 2019 Acıbadem Üniversitesi Kerem Aydınlar Kampüsü
61. 2019 Acıbadem Üniversitesi 1. Beyin Ak Madde Diseksiyon Kursu . 31 Ağustos-1 Eylül 2019 . İstanbul . **Derin Beyin Çekirdeklerinin Anatomisi**. , Davetli Konuşmacı, İstanbul, Türkiye 2019
62. 2019 Sinir Sistemi Cerrahisi Derneği 15.Sinir Sistemi Cerrahisi Kongresi **MR Rehberliğinde Derin Beyin Çekirdekleri 3D HDR Mikrocerrahi Anatomisi 3D** 21-24 Kasım 2019 Margi Hotel Edirne
63. 2019 Acıbadem Üniversitesi 1. Endoskopik Kafa Tabanı Kadavra Kursu . 25-26 Mayıs 2019 . İstanbul. **Anterior Kafa Tabanı Menengiomları**, Davetli Konuşmacı, İstanbul, Türkiye
64. 2019 Türk Nöroşirurji Derneği 33. Bilimsel Kongresi 11-14 Nisan 2019. **Menenjiomalarda Moleküler Biyolojik Gelişmeler: Tarihsel Perspektif.** , Davetli Konuşmacı, Antalya, Türkiye
65. 2018 Acıbadem Üniversitesi Kafatabanı Kursu .**Anterior Kafa Tabanı Menengiomları** 1-2 Aralık 2018 , Davetli Konuşmacı, İstanbul, Türkiye
66. 2018 Orta Hat ve Ventriküliçi Yerleşimli Lezyonlar NOVA Sempozyumu. **Bazal Ganglionlar ve Nukleus Anatomisi., Davetli Konuşmacı**, İstanbul, Türkiye
67. 2018 International Endoscopic Skull Base Surgery-Huanhu Symposium, 7th International Microneurosurgical Anatomy Symposium, 1st Rhoton Society Meeting . **3D-HDR Documented , MRI Navigated Microsurgical Anatomy of Human Brain Nuclei and Fiber Systems.** Hüseyin Biçeroğlu 29th June -1st July 20182018 Tianjin ,China, Davetli Konuşmacı, Tianjin, Çin
68. 2018 Neurosurgery . Course Series 7– 4th Prof. Dr. Evandro de Oliveira Skull Base Course , Prof. Rhoton Anatomy Lab BAU Faculty of Medicine, İstanbul, May 18-20, 2018. **3D MRI Navigated Microsurgical Anatomy of Human Brain Nuclei and Fiber Systems.,** Davetli Konuşmacı, İstanbul, Türkiye
69. 2018 Kafa Tabanı Derneği 3. Bilimsel Kongresi, **Kafa Tabanı Cerrahisinde Rekonstrüksyon ,Rehabilitasyon ve Yaşam Kalitesi .** , Davetli Konuşmacı, Antalya, Türkiye
70. 2017 Vestibüler Schwannoma ve İnfratentorial Vasküler Lezyonlar ,Nova 2017 Sempozyumu. **Temporal Kemik Cerrahi Anatomisi: “Disseksiyonun Önemi”** , Davetli Konuşmacı, İstanbul, Türkiye

71. 2017 World Federation of Neurosurgical Societies 16.World Congress of Neurosurgery. **History of White Matter Research** August 20-25 2017 Istanbul Congress Center Turkey. Davetli Konuşmacı, İstanbul, Türkiye
72. 2017 World Federation of Neurosurgical Societies 16.World Congress of Neurosurgery. **Breakfast Seminars 46** Eduardo Seana Argentina Huseyin Biceroglu Turkey. August 20-25 2017 Istanbul Congress Center Turkey. Oturum Başkanı, İstanbul, Türkiye
73. 2017 TND Cerrahi Nöroanatomi ve Nörovasküler Eğitim ve Öğretim Grupları Ortak Sempozyumu İntrakranial Anevrizmalar Sempozyumu .**Anterior Koroidal Arter Anatomisi.** , Davetli Konuşmacı, Mersin, Türkiye
74. 2017 North American Skull Base Society 27th Annual Meeting "Mastery and Legacy in Skull Base Surgery: Lessons in Synchronicity" March 3-5, 2017 The Roosevelt New Orleans, New Orleans, Louisiana Pre-Meeting Course: March 1-2, 2017 LSU Health Sciences Center, New Orleans, Louisiana **Dr. Albert L. Rhoton Memorial Honorary Guest**
75. 2016 Türk Nöroşirurji Derneği 30. Bilimsel Kongresi, Sabah Semineri **. Üçüncü Ventrikül Patolojilerinde Endoskopik Yaklaşımda Cerrahi Mikroanatomi: Transventriküler, Transsfenoidal, Posterior Yaklaşım ,** 8-12 Nisan 2016 .Davetli Konuşmacı, Antalya, Türkiye
76. 2016 Türk Nöroşirurji Derneği 30. Bilimsel Kongresi, **Sözlü Bildiriler 15/ Nörovasküler Cerrahi Oturum Başkanları** Pınar Özışık , Hüseyin Biçeroğlu 8-12 Nisan 2016, Oturum Başkanı , Antalya, Türkiye
77. 2015 International Symposium on Microsurgical Anatomy. 6th ISMA. 8- 10 Ekim 2015 .İstanbul.**MR Navigated Microsurgical and Functional Anatomy of Nuclei and Fibers of Central Core** . , Davetli Konuşmacı, İstanbul, Türkiye
78. 2015 60.Yıl Onuruna Ege Üniversitesi Beyin Fonksiyonel ve Kognitif Mikrocerrahi Anatomisi Sempozyumu. **Central Core ve Ak Maddenin MR Korrele Mikrocerrahi Anatomisi 3D Anatomik Sunum** . , Davetli Konuşmacı, İzmir, Türkiye
79. 2015 60.Yıl Onuruna Ege Üniversitesi Beyin Fonksiyonel ve Kognitif Mikrocerrahi Anatomisi Sempozyumu**. Beynin Fonksiyonel ve Kognitif Mikrocerrahi Anatomisi Tarihçesi** , Davetli Konuşmacı, İzmir, Türkiye
80. 2015 Türk Nöroşirurji Derneği 29. Bilimsel Kongresi, Kaya Palazzo Kongre Merkezi , Antalya .Panel 17 : **Omurilik Tümörleri.** (Panelist .Konuşmacı) , Panelist, Antalya, Türkiye
81. 2015 Türk Nöroşirurji Derneği 29. Bilimsel Kongresi, Kaya Palazzo Kongre Merkezi , Antalya .**Sözlü Bildiri 13 . Cerrahi Nöroanatomi ve Pediatrik Nöroşirürji Oturum Başkanları** Dr. Hüseyin Hayri Kertmen , Dr. Hüseyin Biçeroğlu , Oturum Başkanlığı Antalya, Türkiye
82. 2015 60. Yıl Onuruna Ege Üniversitesi 1. Endoskopik Kafatabanı Cerrahisi Sempozyumu . **Sellar,Parasellar ve Kafatabanının Endonöroşirurjikal Mikrocerrahi Nöroanatomisi**. , Davetli Konuşmacı, İzmir, Türkiye
83. 2015 International Deep Brain Stimulation Surgery&Microelectrode Recording Cadaver Course, February 06-07 2015, Istanbul. **3D MRI Navigated Functional ,Behavioral and Cognitive Microsurgical Neuroanatomy of Central Core .** , Davetli Konuşmacı, İstanbul, Türkiye
84. 2015 Türk Nöroşirürji Derneği Cerrahi Nöroanatomi Öğretim ve Eğitim Grubu . İntrinsik Beyin Lezyonları İçin Ak Madde Yollarının Üç Boyutlu Mikroanatomisi ve Cerrahisi Toplantısı . **Geçmişten günümüze ak madde yolları ,** Davetli Konuşmacı, Ankara, Türkiye
85. 2014 Kocaeli Üniversitesi Hipofiz Araştırma Merkezi İleri Endoskopik Kafa Kaidesi ve Hipofiz Cerrahisi Kadavra Kursu. 26-28 Eylül 2014 ,Kocaeli. **Endoskopik Endonazal Anatomi ve Anterior Kafatabanı Yaklaşımları.** (ek konuşma), Davetli Konuşmacı, Kocaeli, Türkiye
86. 2014 1st ASNO Skullbase Anatomy Course : Hands on Cadaveric Workshop , as an invited Faculty. September 10-11, 2014 İstanbul , Turkey .**Endoscopic Endonasal Anatomy and Approaches to Anterior Skull Base.** , Davetli Konuşmacı, İstanbul, Türkiye
87. 2014 Kafatabanı Cerrahisi Kursu. Prof.Dr.Rhoton Anatomi Laboratuarı Resmi Açılışı. Bahçeşehir Üniversitesi .**Lateral Skull Base Approaches : Presigmod Approach**., Davetli Konuşmacı, İstanbul, Türkiye
88. 2013 Kafa Tabanı Cerrahisi Kadavra Kursu . İstanbul Marmara Üniversitesi Nörolojik Bilimler Enstitüsü **Anterior Fossa Yaklaşımlarında Kognisyon , Konuşma ve Davranışın Mikrocerrahi Anatomisi ,** Davetli Konuşmacı, İstanbul, Türkiye

89. 2012 Sinir Sistemi Cerrahisi Derneği 8. Bilimsel Kongresi. **Konuşmanın Mikrocerrahi Anatomisi.,** Davetli Konuşmacı, Gaziantep, Türkiye
90. 2012 3rd International Levantine Forum .''Advances in Neurological Surgery''**Microsurgical Anatomy of Cognitive Neurosurgery** 15-18 November 2012 Sheraton Çeşme Hotel Çeşme/İzmir-Turkey Davetli Konuşmacı, İzmir, Türkiye
91. 2012 Türk Nöroşirürji Derneği Cerrahi Nöroanatomi Öğretim ve Eğitim Grubu , Beynin Fonksiyonel Organizasyonu ve Bağlantı Yolları Kursu .**Serebrumun Ak Madde Yollarına ve Derin Nukleuslarına 3D Bakış,** 13-14 Eylül 2012 Yeditepe Üniversitesi Hastanesi. Davetli Konuşmacı, İstanbul, Türkiye
92. 2012 Türk Nöroşirürji Derneği Cerrahi Nöroanatomi Öğretim ve Eğitim Grubu , Beynin Fonksiyonel Organizasyonu ve Bağlantı Yolları Kursu . **Operasyon Mikroskobu ve Üç Boyutlu Ekranla Beynin Topografik Fonksiyonel Anatomisinin Gösterilmesi, Sulkuslar Giruslar , 1**3-14 Eylül 2012 Yeditepe Üniversitesi Hastanesi. Davetli Konuşmacı, İstanbul, Türkiye
93. 2012 4th International Symposium of Clinical and Applied Anatomy (ISCAA) 28 June- July01 2012 .Ankara,Turkey. **Microsurgical Anatomy of Cognitive Neurosurgery.** (Guest speaker invited oral presentation). , Davetli Konuşmacı, Ankara, Türkiye
94. 2012 A Celebration of the Art and Science of Teaching Neurosurgery recognizing Dr. Albert Rhoton's 40 years at the University of Florida, January 2012, Gainesville, Florida. **Honorary Guest as a Rhoton Fellow**
95. 2011 **3D Anatomy of the Brain** .Second Annual Neuroanatomy Day. Duval Country Public Schools . Jacksonville USA 3 -4 February 2011 as a guest speaker, Konferans, Medtronic, Türkiye
96. 2011 **Fiber Pathways of Brain under new conceptual developments.** Huseyin Biceroglu, Albert L. Rhoton. University of Florida Department of Neurosurgery Morning Conference.. DeWeese Auditorium LG-101 . Friday, December 17th 2011, Konferans, University of Florida, Amerika Birleşik Devletleri
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98. 2010Türk Nöroşirürji Derneği Cerrahi Nöroanatomi Öğretim ve Eğitim Grubu 2010 Kursu, / **Serebrumda Sulkus ve Giruslar: Ak Madde Yollarının Tanımlanması** , Davetli Konuşmacı, İstanbul, Türkiye
99. 2010 Türk Nöroşirürji Derneği Cerrahi Nöroanatomi Öğretim ve Eğitim Grubu 2010 Kursu, **Yeni Kavramsal Gelişmeler Altında Beyin ve Limbik Sistem Yolları** , Davetli Konuşmacı, İstanbul, Türkiye
100. 2010 Feyyaz Berkay Günleri, **Serebrum Ak Madde Yolları** Davetli Konuşmacı, İstanbul, Türkiye

ETKİNLİK ORGANİZASYONLARINDAKİ GÖREVLER

1. 3 Internatıonal Rhoton Socıety Meetıng August 22 - 24, 2023 Future Of Mıcroneurosurgery August 25, 2023 Y-Sıttıng Posıtıon In Neurosurgery August 26, 2023 Elite World Asia Hotel – Istanbul Scientific Committee
2. 22 Mart 2018 **Biçeroğlu H.,** Kafa Tabanı Derneği 3. Bilimsel Kongresi, Kongre Bilimsel Kurul Üyeliği , Bilimsel Kongre / Sempozyum Organizasyonu, Antalya, Türkiye
3. 08 Nisan 2016 **Biçeroğlu H.,** Türk Nöroşirurji Derneği 30. Bilimsel Kongresi,Antalya Kongre Bilimsel Danışma ve Kongre Bildiri Değerlendirme Kurulu , Bilimsel Kongre / Sempozyum Organizasyonu, Antalya, Türkiye
4. 05 Haziran 2015 **Biçeroğlu H**., 60.Yıl Onuruna Ege Üniversitesi Beyin Fonksiyonel ve Kognitif Mikrocerrahi Anatomisi Sempozyumu.**Sempozyum Direktörlüğü,** Bilimsel Kongre / Sempozyum Organizasyonu, İzmir, Türkiye
5. 28 Mart 2015 **Biçeroğlu H.,** 60. Yıl Onuruna Ege Üniversitesi 1. Endoskopik Kafatabanı Cerrahisi Sempozyumu . **Sempozyum Direktörlüğü** , Bilimsel Kongre / Sempozyum Organizasyonu, İzmir, Türkiye
6. 04 Nisan 2014 **Biçeroğlu H**., Türk Nöroşirurji Derneği 28. Bilimsel Kongresi, Kongre Bilimsel Danışma ve Kongre Bildiri Değerlendirme Kurulu, Bilimsel Kongre / Sempozyum Organizasyonu, Antalya, Türkiye

VERDİĞİ KURS VE EĞİTİMLER

1. 2024 13th International Meningioma Society Meeting , Microsurgical and Endoscopic Anatomy and Approaches for Skull Base Meningiomas with Special Emphasis on Cerebral Venous SystemPre-Meetıng Course 8th May 2024
   (Course Faculty)

2. 2024 Acıbadem Mehmet Ali Aydınlar Üniversitesi 4th Skullbase Approaches Course Hands on Cadaver Workshop. **Posterior Petrozal Yaklaşım** Hüseyin Biçeroğlu 2-3 March 2024
   (Course Faculty- Master Desk- Laboratuar Eğitmeni)

3. 2023 Acıbadem Mehmet Ali Aydınlar Üniversitesi 3rd White Matter Dissection Course **Medial Surface Anatomy Medial to Lateral Dissection Technique Hand On Cadaveric Dissection** Hüseyin Biçeroğlu 9-10 December 2023
   (Course Faculty- Master Desk- Laboratuar Eğitmeni)

4. 2023 Acıbadem Mehmet Ali Aydınlar Üniversitesi 4.Kafatabanı Kadavra Kursu **Posterior Petrozal Yaklaşım** Hüseyin Biçeroğlu 14-15 Ocak 2023
   (Course Faculty- Master Desk- Laboratuar Eğitmeni)

5. 2023 Acıbadem Mehmet Ali Aydınlar Üniversitesi 3rd Annual Endoscopic Skull Base Cadaver Course, Hüseyin Biçeroğlu Acibadem University's CASE Neuroanatomy Laboratory in Istanbul from October 14th to 15th, 2023.
   (Course Faculty-Laboratuar Eğitmeni)

6. 2022 Biçeroğlu H. İzmir Tınaztepe Üniversitesi I. Endoskopik Kafa Tabanı Kadavra Kursu 23.04.2022 - 24.04.2022
   (Laboratuar Eğitmeni)

7. 2021 Acıbadem University II. White Matter Dissection Course and Surgery of Gliomas - Masters with Turkish Rhoton Fellows Group . 7 May 2021 . Uluslararası Online Webinar
   (Course Director)

8. 2021 Acıbadem University II. Endoscopic Skull Base Course(Online) Masters with Turkish Rhoton Fellows Group. 23 January 2021 Uluslararası Online Webinar
   (Course Director)

9. 2020 Acıbadem University III. Skull Base Course (Online) Topic: Online Skull Base Course - Masters with Turkish Rhoton Fellows 7,8,14 and 15th November 2020. Uluslararası Online Webinar
   (Course Director)

10. 2020 Biçeroğlu H., Acıbadem Üniversitesi II. Kafa Tabanı Kadavra Kursu
    (Course Faculty. Master Desk- Laboratuar Eğitmeni)

11. 2019 Biçeroğlu H., Acıbadem Üniversitesi 1. Beyin Ak Madde Diseksiyon Kursu . 31 Ağustos-1 Eylül 2019 . Acıbadem Üniversitesi Case Laboratuarı İstanbul .
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12. 2019 Biçeroğlu H., Acıbadem Üniversitesi 1. Endoskopik Kafa Tabanı Kadavra Kursu . 25-26 Mayıs 2019 . Acıbadem Üniversitesi Case Laboratuarı İstanbul
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13. 2018 Biçeroğlu H., Acıbadem Üniversitesi Kafatabanı Kursu .1-2 Aralık 2018 . Acıbadem Üniversitesi Case Laboratuarı İstanbul.
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14. 2018 Biçeroğlu H., Course Series 7– 4th Prof. Dr. Evandro de Oliveira Skull Base Course , Prof. Rhoton Anatomy Lab BAU Faculty of Medicine, İstanbul, May 18-20, 2018.
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15. 2015 Biçeroğlu H., International Symposium on Microsurgical Anatomy. 6th ISMA. Pre-Meeting Cadaver Course 17-18 Ekim 2015 .İstanbul.
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(Laboratory Faculty)

17. 2015 Biçeroğlu H. International Deep Brain Stimulation Surgery&Microelectrode Recording Cadaver Course, Prof. Rhoton Anatomy Lab BAU Faculty of Medicine February 06-07 2015, Istanbul
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18. 2014 Biçeroğlu H., 1st ASNO Skullbase Anatomy Course : Hands on Cadaveric Workshop , as an invited Faculty. September 10-11, 2014 İstanbul , Turkey
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19. 2014 Biçeroğlu H. Kocaeli Üniversitesi Hipofiz Araştırma Merkezi İleri Endoskopik Kafa Kaidesi ve Hipofiz Cerrahisi Kadavra Kursu. 26-28 Eylül 2014 ,Kocaeli.
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21. 2013 Biçeroğlu H., Kafa Tabanı Cerrahisi Kadavra Kursu . İstanbul Marmara Üniversitesi Nörolojik Bilimler Enstitüsü 20-21 Eylül , 2013
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22. 2012 Biçeroğlu H. Türk Nöroşirürji Derneği Cerrahi Nöroanatomi Öğretim ve Eğitim Grubu , Beynin Fonksiyonel Organizasyonu ve Bağlantı Yolları Kursu . **1**3-14 Eylül 2012 Yeditepe Üniversitesi Hastanesi.
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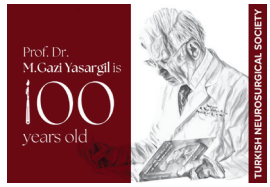

Accuracy of Deep Brain Stimulation Lead Placement Using a Cranial Robotic Guidance Platform: A Preliminary Cadaveric Study

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ABSTRACT

AIM: To measure the deviation rate of a custom 3D-printed Deep Brain Stimulation (DBS) lead holder assisted electrode placements from their intended targets, providing a benchmark for the system's accuracy and paving the way for its use in standard DBS workflows.

MATERIAL and METHODS: The study was conducted in an experimental lab using a cadaver obtained according to local regulations. Planned electrode trajectories, designed with Medtronic's DBS surgery planning system, were transferred to the StealthStation Autoguide. A 3D-printed DBS lead holder with integrated navigation fiducials was used to place six electrodes in the targeted brain regions. Pre-operative CT and MRI scans were used for planning, and post-operative imaging confirmed electrode placement. Deviation from planned trajectories was analyzed using Python to assess accuracy.

RESULTS: Following a 30-minute registration and draping process, the median electrode placement time was 22.5 minutes (range: 15-120). The total surgical time for all six electrodes was approximately 5 hours, including imaging, adjustments, and confirmation. The median difference was 1.73 mm (0.03-5.45) on the X-axis, 1.86 mm (0.46-2.74) on the Y-axis, and 1.95 mm (0.73-4.4) on the Z-axis. The median vectorial difference was 2.68 mm (2.3-6.71), while the median trajectory difference was 3.01 mm (1.64-6.63).

CONCLUSION: Despite 50% of leads having a vectorial difference exceeding 4 mm, most had a trajectory difference of less than 3 mm, which could be attributed to the inability to measure the length of the electrode precisely. These results suggest that with minor adjustments, the StealthStation Autoguide could be a cost-effective alternative to similar systems, though further cadaveric studies are necessary to address potential learning curves and random factors.

KEYWORDS: Deep brain stimulation, Electrode placement, Parkinson's disease, Placement accuracy, Robot-assisted

ABBREVIATIONS: 3D: Three-Dimensional, **CNC:** Computer Numerical Control, **CT:** Computed Tomography, **DBS:** Deep Brain Stimulation, **FDM:** Fused Deposition Modeling, **GPi:** Globus Pallidus Interna, **MRI:** Magnetic Resonance Imaging, **PLA:** Polylactic Acid, **SPSS:** Statistical Package for the Social Sciences, **STL:** Stereolithography, **STN:** Subthalamic Nucleus, **TPU:** Thermoplastic Polyurethane, **Vim:** Ventral Intermediate Nucleus

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INTRODUCTION

Deep brain stimulation (DBS) is a widely used procedure for various movement disorders. However, its treatment efficacy is dependent on the accuracy of the electrodes. While effective, traditional stereotactic methods are less comfortable for the patient, as the patient has to be placed in a frame to obtain an MRI and then brought back to the operating room and have a longer duration (both overall and per electrode) than frameless methods (8,10,18,26).

Frameless placement of the DBS electrodes is a proven procedure used since 2019 (5,8,10,15,21,26). These systems either use highly specialized platforms that, after the navigation system specifies the insertion point, allow controlled drive into the target location (e.g., Nexframe® DB2040; Medtronic Neurological Division, Dublin, Ireland) or use a robot with a freely moving arm (e.g., now discontinued Mazor Robotics Renaissance® system (Mazor Robotics Ltd, Caesarea, Israel) and ROSA® robot (Zimmer Biomet, Warsaw, Indiana, USA). These systems may require more investment than compact systems such as StealthStation Autoguide (Medtronic, Dublin, Ireland).

Beyond DBS, robotic surgery has been increasingly adopted in various neurosurgical procedures, offering enhanced precision, reduced operative times, and improved patient outcomes. The integration of robotic systems into neurosurgery facilitates minimally invasive approaches, enhances surgical accuracy, and improves overall workflow efficiency, thereby expanding the capabilities and applications of neurosurgical interventions (1,3,4,6).

However, no studies explore the possibility of utilizing custom-made lead holders with the StealthStation Autoguide system in DBS placement. This study seeks to measure the deviation of the placed electrodes from their intended targets on a cadaveric model, providing a benchmark for the system's accuracy and reliability. It also serves as a preliminary study to justify further research.

MATERIAL and METHODS

Cadaver Preparation

This study was conducted at the Ege University Faculty of Medicine, utilizing a cadaver obtained following Turkish Law No. 2238. The local institutional review board approved the research protocol, ensuring adherence to ethical standards for using human cadaveric material in research (Decision no: 24-3.1T/40, Date: 21.03.2024).

A single cadaver with an intact calvarium was obtained from the Ege University Faculty of Medicine, Department of Anatomy. The cadaver was imaged pre-operatively to plan the trajectories for electrode placement. We used computed tomography (CT) and magnetic resonance imaging (MRI) per our local protocol for DBS placement. MRI studies were performed using a 3.0 Tesla MRI system (Magnetom® Verio, Siemens, Erlangen, Germany), and a 16-channel head coil, T2 SPACE sequence, and T1-MPRAGE pulse sequence were used. The CT scan was performed on a 64 detector 128 sliced CT scanner (Siemens Somatom Definition AS, Siemens, Erlangen, Germany).

Medtronic DBS model 3389 leads with 28 cm length and 2 Medtronic DBS model 3389 leads with 40 cm leads were available and were used in this study.

Surgical Planning

Using the StealthStation S8 planning station Version 1.3.2 (Medtronic, Dublin, Ireland) for DBS surgery, trajectories for the subthalamic nucleus (STN), Globus pallidus interna (GPi), and ventral intermediate nucleus (Vim) on both hemispheres of the brain were auto-calculated and then modified by an experienced neurosurgeon and neurologist. These plans were then transferred to the StealthStation Autoguide robotic system, which was used to guide the placement of six DBS electrodes (three on each side).

Electrode Placement

Currently, the StealthStation Autoguide system does not have a holder for DBS electrodes. Thus, the biopsy module and its cannula were used to design the custom 3D-printed DBS lead holder (STL files can be found at https://github.com/AkbulutBB/DBSNav). The files were then printed using a fused deposition modeling 3D printer Ender-3 S1(Creality, Shenzen, China) with polylactic acid(PLA).

In the biopsy module, the guidance system only works within a single axis after the trajectory is locked. It requires two fiducials arranged in a single line and placed within a specific distance of each other (Figure 1A). Thus, the fiducials were placed within two cavities that were made within the holder, and a hole for the electrode to pass was placed using a drill within the fiducials.

The cadaver was positioned in the operating room (Figure 2), and the StealthStation Autoguide system was set up according to the pre-operative plans. The target distance was calculated using the provided measurement tool for biopsy cannulas (Figure 1B), and DBS electrodes were locked in the desired length using a screw-tightened system. The system's robotic arm was used to guide the DBS lead holder, ensuring precise alignment with the planned trajectories.

To guide the leads, a STar Array Lead Insertion Tube was inserted through the StealthStation Autoguide biopsy system, 5 cm proximal to the target. Then, the electrodes were inserted using the 3D printed tool to stop the leads at the correct depth (Figure 3). After placement, an X-ray image was obtained to account for any displacement when retracting the robotic system. While lead was held in place using bayonet forceps, the custom DBS holder was disengaged using the screw system, and then the robot arm was carefully retracted. After obtaining another X-ray image, ensuring the lead was not moved during this retraction process, it was locked in place by the burr hole covers provided with the leads.

After all leads were placed, the skin was approximated using silk sutures, and the cadaveric head was carefully placed in the transportation box.

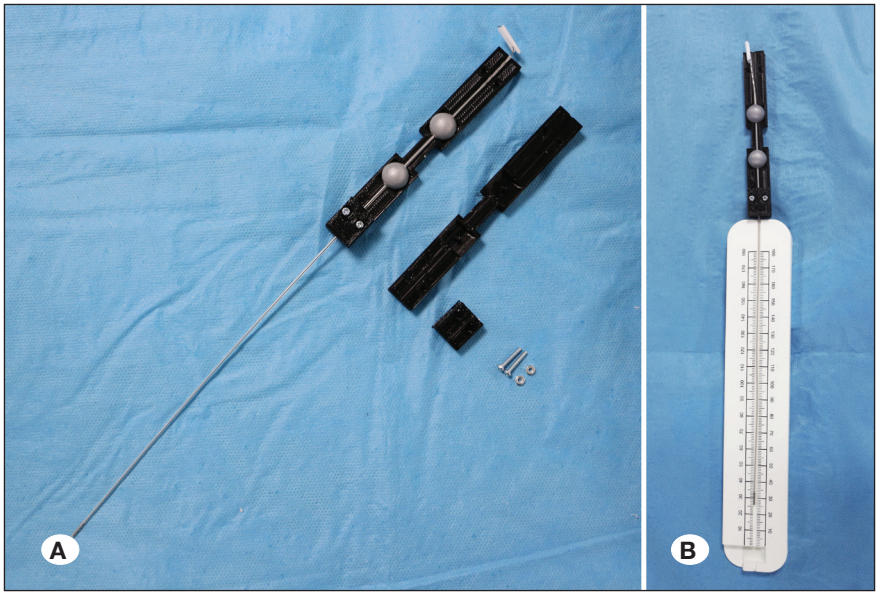

Figure 1: A) Two fiducials are arranged specifically with a DBS electrode passing through. **B)** Measuring tool with screw-tightened locking mechanism.

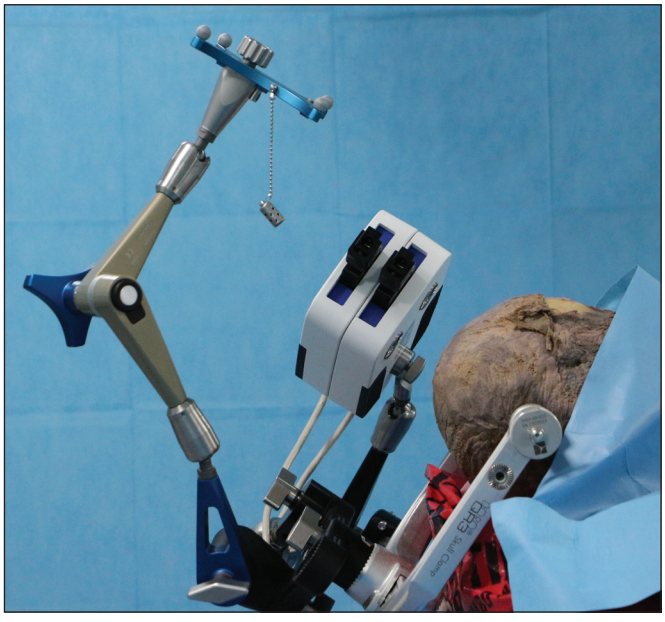

Figure 2: Cadaver with Stealth Station Autoguide in position.

Post-operative Imaging and Analysis

Following electrode placement, CT and MRI scans were repeated with the preoperative protocols to confirm the actual locations of the electrodes. Accuracy was assessed using the method proposed by Burchiel et al. (2), where the difference between the intended and actual trajectory (trajectory difference) and the difference between the intended end-point of the electrode and the actual electrode (vectorial difference) is calculated using the post-operative scans. Coordinates were obtained from the StealthStation system, the difference between intended and actual electrode coordinates was calculated, and 3D vector fields were drawn using the Python libraries Matplotlib and Numpy (12,13). Details of the code can be found in our code repository (https://github.com/AkbulutBB/DBSNav).

Statistical Analysis

The collected data were analyzed using IBM SPSS Statistics Version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated for each electrode placement. No comparative analysis was made as this is a preliminary study involving one cadaver.

RESULTS

After registration and the draping was complete (approximately 30 minutes), the actual electrode placement process took a median time of 22.5 minutes per electrode. The overall surgical time for placing all six electrodes was approximately 5 hours. This time includes the necessary imaging, adjustments, and confirmation steps. Details can be found in Table I.

Using coordinates obtained from StealthStation, the differences in 3 axes, vectorial, and trajectory differences were calculated (Table II). The median difference was 1.73 mm on the X-axis, 1.86 mm on the Y-axis, and 1.95 mm on the Z-axis. The median vectorial difference was 2.68 mm, while the median trajectory difference was 3.01 mm. Figures 4, 5, and 6 provide visual representations of the planned trajectories and the actual placements.

DISCUSSION

The preliminary results of our study demonstrate the potential of the StealthStation Autoguide system for DBS lead placement in a cadaveric model, warranting further research to improve upon our design and possibly match the accuracy of more specialized robotic platforms.

We created and employed a specialized 3D-printed DBS lead holder due to the lack of a commercially accessible holder for DBS electrodes compatible with the StealthStation Autoguide.

Table I: Placement Time and Coordinates of Electrodes

No	Electrode	Time (min)	I-X	I-Y	I-Z	A-X	A-Y	A-Z
1	L STN	120	135.56	135.72	145.93	135.37	134.89	143.31
2	L Gpi	45	146.38	130.16	148.81	140.93	129.7	152.69
3	L Vim	25	137.08	138.39	149.61	136.91	139.07	147.11
4	R STN	20	111.56	135.46	145.93	113.48	133.66	142.72
5	R Gpi	15	100.86	129.67	148.82	100.89	127.49	148.09
6	R Vim	20	109.98	138.1	149.61	111.69	135.36	145.21

The X-axis is the medial-lateral axis, The Y-axis is the anterior-posterior axis, and the Z-axis is the superior-inferior axis in this context. "I" stands for intended, and the "A" stands for the actual coordinates. ***Abbreviations: STN:*** *Subthalamic Nucleus,* ***GPi:*** *Globus Pallidus Interna,* ***Vim:*** *Ventralis Intermediate Nucleus*

Table II: Differences in Different Axes in the Actual Electrode Position and the Planned Coordinates

No	Electrode	Delta-X (mm)	Delta-Y (mm)	Delta-Z (mm)	Vectorial Difference (mm)	Trajectory Difference (mm)
1	L STN	0.19	0.83	2.62	2.75	1.91
2	L Gpi	5.45	0.46	-3.88	6.71	6.63
3	L Vim	0.17	-0.68	2.5	2.6	1.64
4	R STN	-1.92	1.8	3.21	4.15	3.16
5	R Gpi	-0.03	2.18	0.73	2.3	2.08
6	R Vim	-1.71	2.74	4.4	5.46	2.86

Vectorial difference and trajectory difference are calculated through the process provided in the methods. ***STN:*** *Subthalamic Nucleus,* ***GPi:*** *Globus Pallidus Interna,* ***Vim:*** *Ventralis Intermediate Nucleus.*

Figure 3: The 3D-printed tool stops the lead at the correct depth.

Although our custom holder allowed the electrode placement, future versions could be enhanced to overcome the limitations of StealthStation's biopsy length calculation tool. This could enable lead advancement by 0.1 mm intervals, similar to traditional insertion systems, potentially leading to improved lead placement accuracy.

It should also be noted that fused deposition modeling, which has been used to print the DBS holder, has a reported 0.08-3.14% manufacturing accuracy (19). This means some deviations from the target may have been caused by warping and deformation during the printing process. This may be reduced by using computer numerical control (CNC) machining and industrial-grade calibration techniques.

While there is no clear literature on what constitutes a malposition, most authors report their vectorial difference is less than 3mm and consider revision when it is more than 3 mm. In comparison, 4 mm can be considered unacceptable by all accounts (2,5,7,9,16,17,22,23,27). In our experiment, while half of the leads had a high vectorial difference (more than 4 mm), the majority of the leads had a trajectory difference of less than 3 mm, possibly explained by the inability to measure the length of the electrode precisely, and extended the electrode deeper than planned. This was also partially caused by challenges in visualizing the real-time trajectory of the electrodes on the StealthStation Autoguide screen. This difficulty

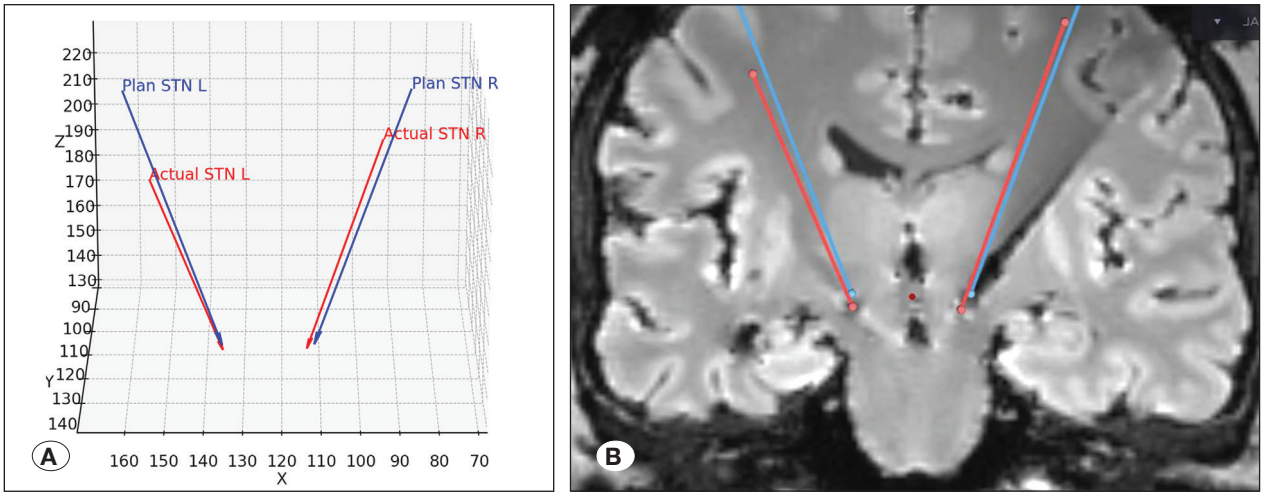

Figure 4: 3D vector field **(A)** and the StealthStation images **(B)** for intended electrode vectors (blue arrows) and the electrodes placed for the STN (red arrows).

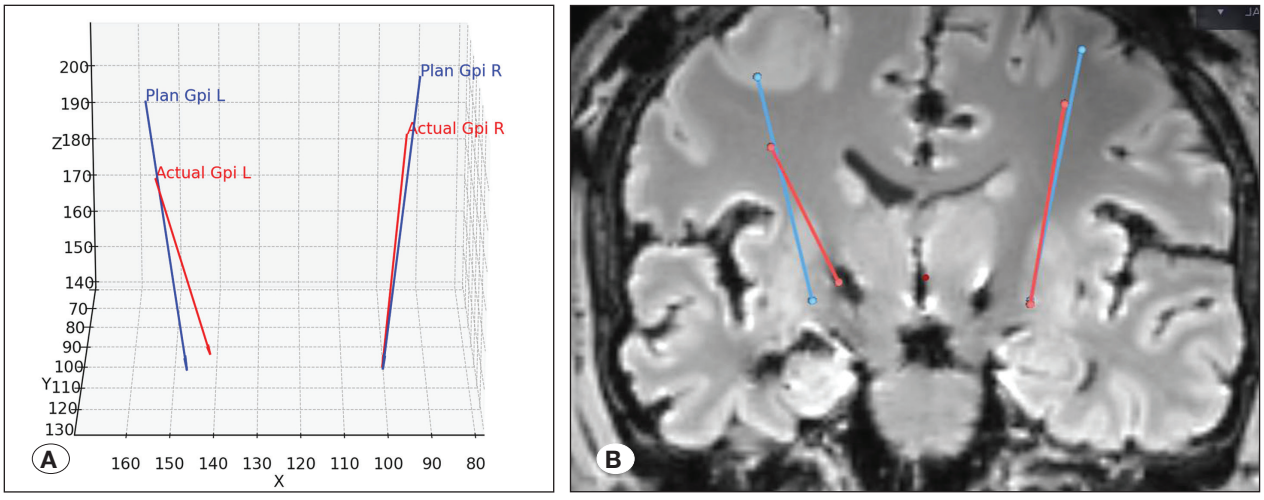

Figure 5: 3D vector field **(A)** and the StealthStation images **(B)** for intended electrode vectors (blue arrows) and the electrodes placed for the Gpi (red arrows).

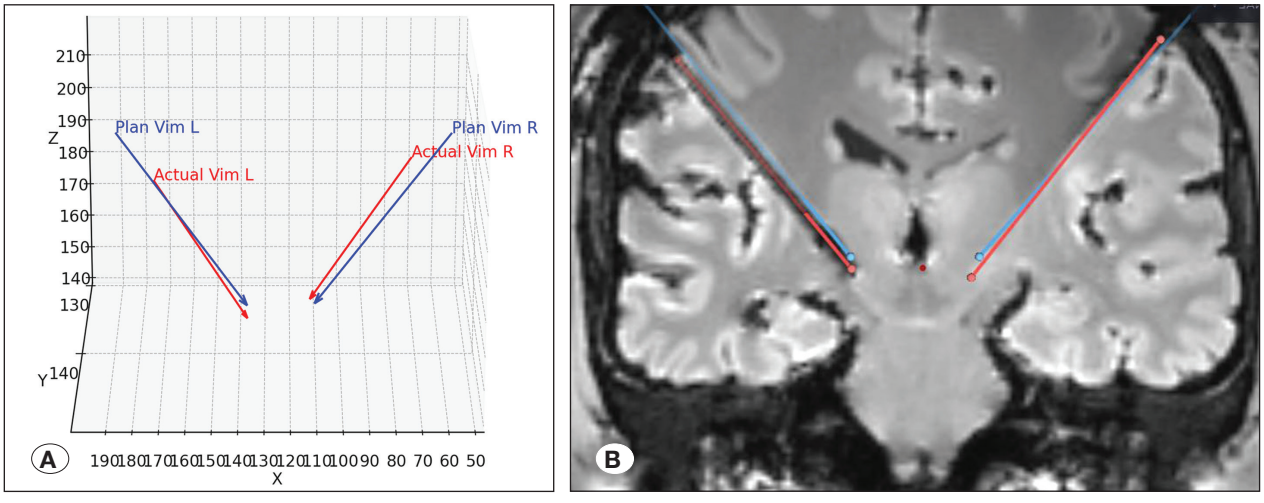

Figure 6: 3D vector field **(A)** and the StealthStation images **(B)** intended electrode vectors (blue arrows) and the electrodes placed for the Vim (red arrows).

arose because the targets for DBS placement were located further from the biopsy cannula, which the system is primarily designed for. Enhancing the system's capabilities to provide real-time feedback for our specialized DBS lead holder could improve accuracy and operator confidence in further research.

An interesting observation is that the duration of the surgery significantly reduced as the primary surgeon felt more at ease with the design. Although the learning curve of the Autoguide platform may have contributed to this, the primary surgeon had ample expertise in both DBS insertion and the utilization of the robotic platform before this. Hence, this occurrence can likely be attributed to the incorporation of our recently developed 3D-printed fiducial holder into the workflow. More cadaveric specimens would be required to minimize the potential variability caused by this.

So, while platforms such as Mazor Robotics Renaissance® system and ROSA® robot offer high-accuracy placement of the DBS leads, their cost may be a barrier for some healthcare organizations, particularly in developing countries, as while their prices are not publicly listed, StealthStation Autoguide is approximately $^{1}/_{5}$ of the price of the Renaissance, and ¼ of the ROSA robotic platform (24). This study serves as an initial exploration of Autoguide's feasibility for DBS lead placement, and future research should investigate its cost-effectiveness compared to other robotic and frame-based systems.

An important constraint of this study is the utilization of only one cadaver. Anatomical variability between specimens can affect the generalizability of our findings. Preliminary studies are crucial for justifying additional research and funding, but bigger sample sizes are required to validate and expand upon these findings. Additionally, the biomechanical properties of a cadaver brain differ significantly from those of a living human brain. The rigidity and fragility of a cadaver brain can potentially impact the precision of electrode positioning. During this study, the increased resistance encountered when inserting the electrodes may have caused bending, resulting in deviations from the intended trajectories (11,20).

Furthermore, the absence of physiological fluids in a cadaver brain may affect its stability and lead to brain tissue displacement during transport as the fixative fluids drain out of the severed cadaveric head. While this phenomenon is not explored in the literature, there are reports of increased brain displacement in patients with CSF over drainage (14,25). This displacement may further contribute to the discrepancies between planned and actual electrode positions. Addressing these differences in future studies by simulating more realistic brain conditions (e.g., fresh frozen cadavers or whole-body cadavers) could improve the findings' relevance to clinical practice.

The precision of the StealthStation Autoguide system's biopsy length calculation tool is a notable limitation. Traditional DBS frames operate with a precision of approximately 0.1 mm, whereas the StealthStation's biopsy calculation tool has a resolution of 1 mm. This issue has not been addressed in the literature, but we believe this lower resolution may have contributed to the observed deviations in electrode placement. Modifying the 3D-printed DBS lead holder for each plan could address this limitation by bypassing the measurement tool's constraints and enhancing placement accuracy.

CONCLUSION

This preliminary study serves as the first step in the implementation of the StealthStation Autoguide cranial robotic guidance platform for DBS surgery. By demonstrating its ability to perform this surgery using a custom 3D-printed DBS holder, our research paves the way for the clinical application of this technology. The potential to shorten surgical times, reduce patient discomfort, and its affordability compared to its counterparts makes Autoguide an appealing option and warrants further research into this topic. Future studies should focus on repeating this work after addressing the technical issues we have encountered and with larger sample sizes. Such research will help refine the technique and build upon our findings, ultimately improving the safety, accuracy, and accessibility of frameless DBS surgery using the StealthStation Autoguide.

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Declarations

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Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author by reasonable request.

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AUTHORSHIP CONTRIBUTION

Study conception and design: HB, SC, AA, TY
Data collection: BBA, OD, OSA, MSB
Analysis and interpretation of results: NA, KEC, CE
Draft manuscript preparation: HB, BBA, MSB
Critical revision of the article: HB, MSB, NA, KEC
All authors (HB, BBA, OD, OSA, MSB, NA, KEC, CE, SC, AA, TY) reviewed the results and approved the final version of the manuscript.

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JNS

CLINICAL ARTICLE

Proof-of-concept study of noninvasive, rapid, machine learning–enhanced, color-based CSF diagnostics: a novel approach to external ventricular drain infection screening

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OBJECTIVE The objective was to develop and validate a proof-of-concept, low-cost, noninvasive device capable of continuously monitoring CSF in external ventricular drainage systems in order to enable earlier detection of infections.

METHODS The authors designed BOSoMetre (CSF-o-Meter), a device that uses a microcontroller and TCS3200 color sensor housed in a 3D-printed chamber for continuous CSF monitoring. The system captures real-time optical measurements across red, green, blue, and clear channels through the external ventricular drain (EVD) tube. Between October 2024 and January 2025, the authors prospectively enrolled 20 patients requiring EVD placement for obstructive hydrocephalus or infection, with 15 included in the final analysis. CSF samples were classified according to Infectious Diseases Society of America 2017 guidelines. The authors processed approximately 4.8 million sensor readings and applied machine learning algorithms using two validation approaches: the subspace k-nearest neighbors (KNN) classifier with 80-20 split validation, and random forest with leave-one-patient-out cross-validation (LOOCV).

RESULTS The subspace KNN classifier with 80-20 split validation yielded 90.4% accuracy with 92% sensitivity and 90.4% specificity (area under the curve [AUC] 0.968). The more stringent random forest with LOOCV approach achieved 81.1% accuracy with 71.5% sensitivity and 89.2% specificity (AUC 0.736). The device successfully distinguished between clean and infected CSF samples, with particularly high specificity in identifying noninfected samples.

CONCLUSIONS BOSoMetre shows promise as a low-cost (< €100), open-source tool for continuous CSF monitoring and early infection detection, especially for resource-limited settings. The high specificity could potentially reduce unnecessary CSF sampling and associated iatrogenic infection risks. Although the initial results are encouraging, further validation in larger cohorts is needed to confirm clinical utility and overcome the technical limitations identified in this proof-of-concept study.

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KEYWORDS cerebrospinal fluid; machine learning; colorimetry; physiological monitoring; hydrocephalus; infection; diagnostic technique

Shunt placement and external ventricular drain (EVD) insertion are among the most frequently performed procedures in neurosurgery.[1] Despite their prevalence, infection rates remain notably high.[2] In cases where a shunt becomes infected, the standard management typically involves removing the device entirely, placing an EVD, and waiting for the CSF to clear before reinserting a new shunt.[3] However, this process requires intermittent CSF sampling. Although culturing the CSF is considered the gold standard for diagnosing infection, its sensitivity is significantly reduced in patients undergoing antibiotic therapy, which includes the majority of this patient popula-

ABBREVIATIONS ABS = acrylonitrile butadiene styrene; AUC = area under the curve; B = blue; C = clear; EVD = external ventricular drain; FDM = fused deposition modeling; G = green; IDSA = Infectious Diseases Society of America; KNN = k-nearest neighbors; LCD = liquid-crystal display; LED = light-emitting diode; LOOCV = leave-one-patient-out cross-validation; MAD = median absolute deviation; PCB = printed circuit board; PVC = polyvinyl chloride; R = red; ROC = receiver operating characteristic; UPS = uninterruptible power supply.

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tion.[4] Additionally, CSF sampling itself is not without risk. While many studies demonstrate a correlation between frequent sampling and higher rates of iatrogenic infections, a handful of investigations challenge this finding.[2,5]

The clarity and colorlessness of CSF have long been recognized as a fundamental characteristic in neurosurgical practice.[6] When infection occurs, CSF may exhibit increased turbidity and a yellow-green discoloration[7] that can be observed through EVD systems. Although these visual changes may parallel clinical improvement as the CSF transitions from turbid to clear, there has been surprisingly little quantitative research examining the spectrophotometric properties of CSF in both normal and pathological states, with many laboratories just using visual inspection of the samples.[8]

In our clinical practice, we observe the macroscopic appearance of CSF in EVD collection chambers,[9] considering visual changes in color and turbidity when making decisions about CSF sampling frequency and timing for permanent shunt placement. However, this assessment is inherently subjective, relying on clinicians' individual experiences and observations. Although the visual appearance of CSF has potential clinical value in our decision-making processes, no standardized tool or objective method is available to quantify these visual characteristics.

To address this need for objective measurement, we developed BOSoMetre (CSF-o-Meter), a proof-of-concept device for CSF monitoring, and present here the preliminary results of our ongoing validation study. The system combines a low-cost color sensor assembly with postprocessing deep learning algorithms to detect potential associations between spectrophotometric changes and CSF infection. All design specifications, hardware components, and source code are publicly available, making this solution accessible to any neurosurgical center.

Methods

Optical Detection System Design and Integration

The TCS3200 light-to-frequency converter was selected as the primary sensing element for our device as it has been reported in the literature for sensitive applications in biological samples.[10–13] This sensor operates on the principle of converting light intensity to a square wave output with frequency directly proportional to light intensity. The sensor's detection array consists of an 8 × 8 photodiode matrix, with each photodiode measuring 110 μm × 110 μm. These photodiodes are arranged in 4 filter groups—red (R), green (G), blue (B), and clear (C) (unfiltered)—that enable selective color detection.

The sensor's filter configuration allows for a programmable color response, with each color channel (R, G, B, and C) being individually selectable through digital inputs. Light passing through these filters strikes the corresponding photodiodes, generating electrical pulses. The frequency of these pulses is measured over a defined sampling period to quantify the intensity of each color component.

The sensor is paired with an indium gallium nitride 5-mm phosphor-coated light-emitting diode (LED) positioned on the opposite side of a custom-designed 3D-printed chamber (Fig. 1A). This chamber was designed using Autodesk Fusion 360 and fabricated using black acrylonitrile butadiene styrene (ABS) material on a Bambu Lab P1S fused deposition modeling (FDM) 3D printer. Studies on similar FDM printers suggest dimensional tolerances of approximately ± 0.3%.[14] The chamber features a slot for the TCS3200 sensor on one side and an LED mount on the opposite side, with a channel designed to accommodate the EVD line (Fig. 1B). The black ABS material and enclosed design create a light-tight environment that shields the sensor from ambient light interference (Fig. 1C), while the chamber's geometry maintains consistent spacing between the sensor, LED, and EVD tubing during measurements (Fig. 1D).

According to the TCS3200 sensor's datasheet, the device provides optimal measurement results with minimal nonlinearity in the 0- to 5-kHz frequency range. Outside this range, the sensor's response to light becomes less predictable, and measurement accuracy may decrease.

To optimize sensor accuracy and minimize measurement deviations, we conducted experiments using distilled water as a reference medium, representing the theoretically maximum clarity achievable in CSF samples. Within a 50-msec measurement window, a 5-kHz frequency output corresponds to approximately 250 sensor activations. We used this threshold as our target maximum and constructed a test setup to evaluate different LED current–limiting resistors to achieve appropriate light intensities.

We selected a 68k-W resistor for LED current limiting based on these experiments and component availability. This resistance value provides appropriate LED brightness to maintain sensor operation within its optimal frequency range while using commonly available components.

Data Acquisition and System Architecture

The device architecture (Fig. 2) is built around an Arduino Micro development board featuring the ATmega32U4 microcontroller, chosen for its integrated USB capabilities and compact form factor. For precise temporal monitoring, the system incorporates a DS3231 real-time clock module, which utilizes a temperature-compensated crystal oscillator (TCXO) to maintain accurate timekeeping with a drift of approximately ± 2 ppm at room temperature.

Data storage is managed through a MicroSD card module operating via the SPI (serial peripheral interface) protocol, allowing for continuous logging of measurements in CSV format. To ensure standardization across multiple devices and minimize assembly-related variations, we designed and manufactured a custom printed circuit board (PCB) that integrates all electronic components.

The user interface consists of a 20 × 4 character I2C liquid-crystal display (LCD) that provides real-time visualization of sensor readings, device status, and patient identification information. Additionally, a high-brightness green LED indicator was implemented for rapid status monitoring from a distance, with different blinking patterns signifying various operational states.

For reliable power management, the system incorporates an uninterruptible power supply (UPS) module coupled with an 18650 lithium-ion battery (1500 mAh), en-

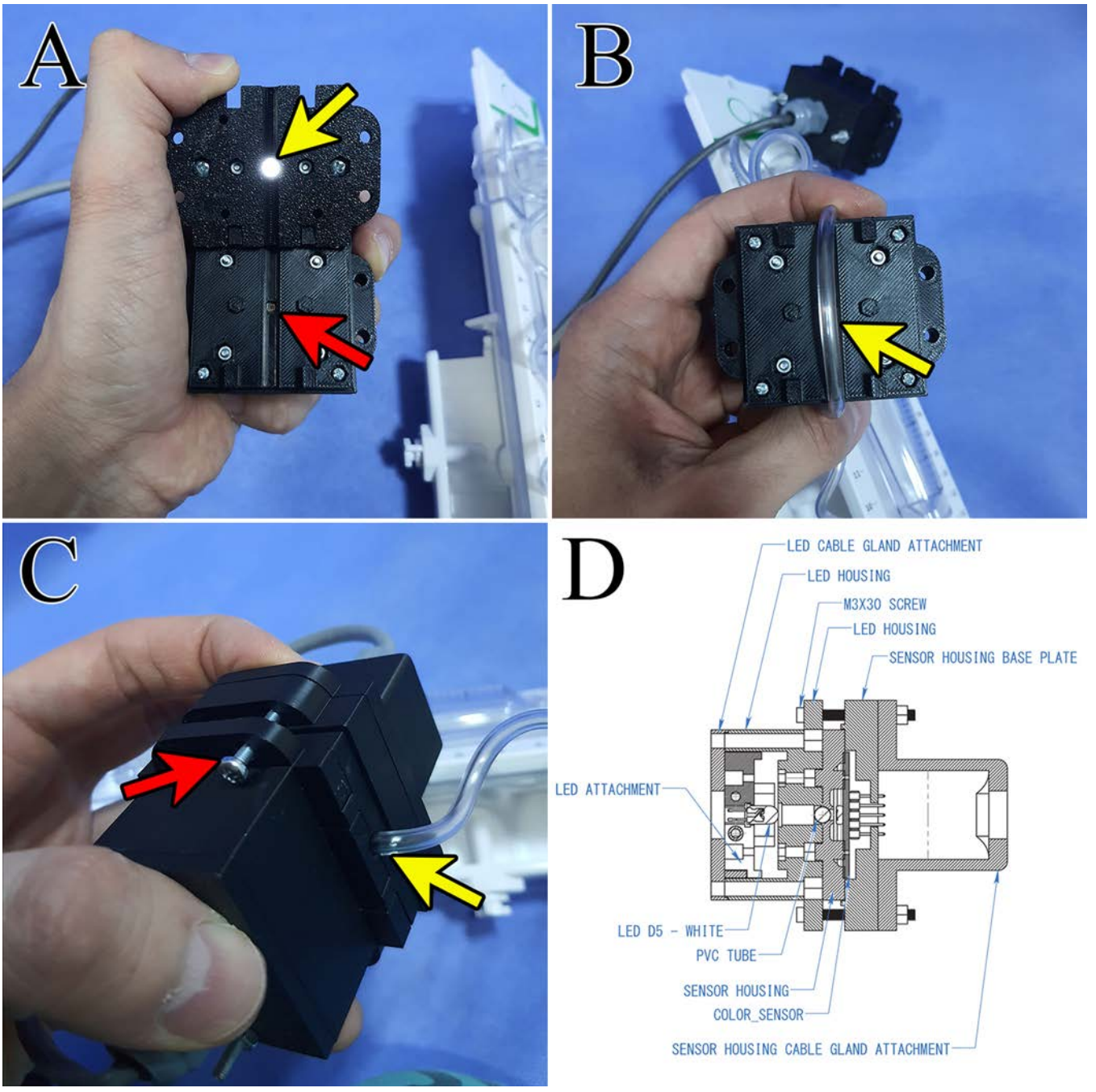

FIG. 1. BOSoMetre sensor assembly and EVD line integration. **A:** The interior design of the 3D-printed black ABS sensor housing shows the LED position (*yellow arrow*) and the TCS3200 color sensor slot visible at the bottom (*red arrow*). **B:** View of the EVD line channel with the EVD line placed into position (*yellow arrow*) showing proper alignment for monitoring. **C:** A side view of the assembled device shows the M3 bolt closure mechanism (*red arrow*) and EVD line exit point (*yellow arrow*), demonstrating the secured light-tight assembly. **D:** Technical cutaway section view depicting the precise arrangement of components, including LED housing, sensor housing, the PVC tube pathway (EVD line), and cable gland attachments that ensure consistent optical measurements and light-tight conditions. Figure is available in color online only.

suring continuous operation during power interruptions. The device operates from a 5-V DC power supply under normal conditions, with an average current draw of approximately 80 mA (0.4 W), theoretically allowing as long as 12 hours of battery-powered operation.

The system was enhanced during the study period by adding a voltage monitoring subsystem for the LED assembly. This modification was implemented after observing that minor voltage fluctuations (± 2.8% from nominal 2.52 V) could influence the TCS3200's readings through variations in LED intensity. The monitoring system allows for post hoc voltage normalization of sensor read-

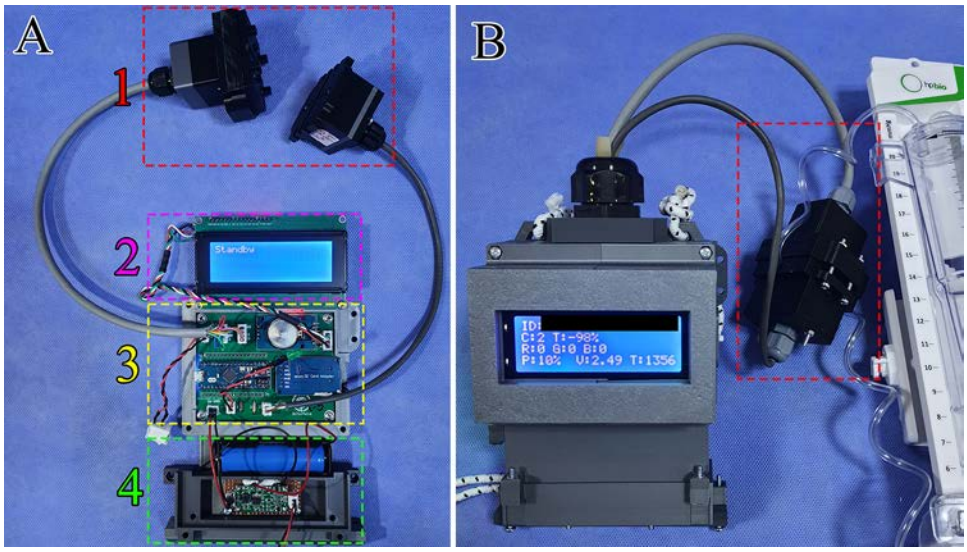

FIG. 2. Modular components and assembly configuration of the BOSoMetre prototype. **A:** Exploded view showing the device's modular components: the sensor assembly enclosed in the *red dashed box* (*1*); LCD module in the *purple dashed box* (*2*); custom PCB board with integrated components in the *yellow dashed box* (*3*); and the power supply unit with UPS board and 18650 battery in the *green dashed box* (*4*). **B:** Clinical setup showing the assembled BOSoMetre device with the LCD (*left*), sensor assembly with integrated EVD line (*red dashed box*) (*middle*), and EVD collection chamber (*right*), demonstrating the complete monitoring system in operation. Figure is available in color online only.

ings, improving measurement reliability. This feature was not present in the first 4 patients enrolled in the study, and this limitation is accounted for in our analysis.

The device's software was designed to sample CSF color characteristics every 2 seconds, with each recorded data point representing an average of 30 measurements taken over 1 minute to minimize noise and ensure measurement stability. The device calculates percentage changes in the R, G, B, and C channels for each measurement cycle relative to the baseline values obtained from clear CSF. While these calculations do not account for voltage-dependent variations in LED intensity, they supply a bedside estimate displayed on the LCD screen for immediate bedside monitoring. The software implements automatic error detection, including power fluctuation monitoring and data integrity checks. All measurements are time-stamped and stored on the SD card in CSV format, allowing for detailed data analysis. The relevant code is available on GitHub (https://github.com/AkbulutBB/BOSoMetre) with GNU General Public License version 3.0.

Patient Selection and Data Collection

This study was conducted in the Department of Neurosurgery at Ege University Hospital between October 2024 and January 2025. We prospectively enrolled all patients, irrespective of age, who underwent EVD placement due to either obstructive hydrocephalus (e.g., aqueductal stenosis, tumor-related obstruction, or congenital causes) or CSF infection (including shunt infections requiring externalization). We excluded patients with hemorrhagic indications for EVD placement, such as subarachnoid or intraventricular hemorrhage. Patients were included regardless of antibiotic status, provided they had a clinical indication for EVD related to obstruction or infection.

The following clinical data were collected: the date of CSF sampling, the unique patient identifier, the unique BOSoMetre device identifier, and EVD-related details including the brand, date of insertion, and total duration of placement. For each CSF sample, we recorded the time of collection, white and red blood cell counts, glucose and protein concentrations, culture results, and the identified organism in cases of culture positivity. At our institution, CSF samples are routinely obtained every 48 hours on weekdays (typically Monday, Wednesday, and Friday) for standard biochemical and microbiological analysis. Additional samples are collected if clinically indicated (e.g., neurological deterioration or fever). No changes were made to the existing clinical sampling protocol for this study. In addition, we recorded relevant blood parameters—including glucose levels, C-reactive protein, and white blood cell count—as well as data regarding antibiotic administration, both qualitatively and as a binary variable.

All patients received a single dose of prophylactic cefazolin, adjusted for age and weight, 30 minutes preoperatively. If postoperative CSF findings confirmed infection, such as elevated white blood cell count, turbidity, or fever, empirical antibiotics were initiated in consultation with the infectious diseases team and subsequently tailored to CSF culture results. If no infection was suspected, patients continued twice-daily cefazolin prophylaxis for the indwelling catheter.

EVD Devices

During the study period, two different brands of EVD devices were used, each with its own set of baseline values. Both devices featured a clear segment of polyvinyl chloride (PVC) tubing leading into the collection chamber, which is central to our evaluation of CSF appearance.

The devices employed were the ArgiFix CSF External Ventricular Drainage and ICP Monitorization System (Argi Grup Sağlık) and the Free Flow External Ventricular Drainage (Hpbio).

CSF Sample Classificatio

Sample classification into infected or noninfected categories was performed based on the reshunting criteria outlined in the 2017 Infectious Diseases Society of America (IDSA) guidelines.[3] Because these classifications were derived from single time-point CSF culture results while the sensor readings provided continuous data, sensor readings corresponding to 2 consecutive CSF culture samples with the same IDSA classification were assigned an identical flag. Conversely, if 2 adjacent CSF culture results yielded different IDSA classifications, the corresponding sensor reading was excluded from analysis, as definitive classification in these ambiguous cases was not feasible. As the dataset grows, these gray areas may eventually be resolved.

Signal Processing and Data Preparation Pipeline

Data preprocessing was performed using Python 3[15] running on Spyder 6.0.3 and utilizing pandas library version 2.2.2,[16] NumPy version 1.26.4,[17] and SciPy version 1.13.1.[18]

The raw data were averaged over hourly intervals to reduce noise and computational overhead while maintaining clinical utility. This was implemented by creating batch indices for every 60 consecutive readings, effectively converting the 1-minute sampling rate to hourly averages. For each batch, both the raw sensor readings (R, G, B, and C channels) and their derived measurements (percentage changes and voltage measurements) were averaged. During this process, any readings where the voltage deviated more than ± 5% from the nominal 2.52 V were excluded from the averaging calculations.

The averaged data were processed through a normalization/winsorization pipeline for outlier handling and data cleaning. This pipeline filtered outliers using a median absolute deviation (MAD)[19] threshold of 5.0, meaning that values more than 5 MADs from the median within an 8-measurement sliding window were identified as outliers. For voltage-based normalization, readings were compensated using a power law relationship with an exponent of 0.1, derived from experimental calibration of the LED intensity response to voltage variations. The winsorization process capped values at the 5th and 95th percentiles of the dataset, ensuring that extreme values did not unduly influence subsequent machine learning analyses while preserving the overall data distribution.[20]

Machine Learning Implementation and Validation Framework

Different methods were explored to analyze the model using an 80-20 validation test split for preliminary analysis and MATLAB R2024a (The MathWorks, Inc.). The subspace k-nearest neighbors (KNN) classifier was implemented with k = 10, using 60 learners and predictors to normalize R, G, B, and C channel values and ratio features (e.g., G/C) at each split. However, since adjacent CSF readings would be similar and thus may create a bleed into test data from the training data and subsequently artificially increase accuracy (temporal data leakage), a leave-one-patient-out cross-validation (LOOCV) analysis was implemented using a random forest approach.

We performed an extensive hyperparameter search for a random forest classifier to detect infection, varying the number of trees, minimum leaf size, screening threshold, maximum splits per tree, and number of predictors per split. The input feature set included normalized R, G, B, and C channel values and ratio features (e.g., G/C). A dynamic windowing approach with window sizes between 2 and 24 hours was employed, governed by a variance threshold of 0.05, and labeled via a majority-voting scheme (the window was labeled clean only if more than half the flags were clean). This approach allowed our model to generate predictions of CSF culture results based on optical characteristics before they were reported (Fig. 3).

The decision threshold for each hyperparameter setting was chosen automatically (via Youden's J statistic) rather than fixed at a particular value. The final performance was assessed under an LOOCV framework to ensure training and testing data independence.

Accuracy, sensitivity, and specificity were reported with 95% exact binomial confidence intervals based on the confusion matrix.

Results

A total of 5 devices were assembled, and 20 patients were initially enrolled in the study. Four patients were subsequently excluded from further analysis due to the absence of voltage-level recordings, and 1 additional patient was removed owing to MicroSD card corruption. Consequently, 15 patients were included in the final analysis. Descriptive characteristics of the patient cohort are detailed in Table 1.

A total of 103 microbiological cultures were performed, and together with other clinical markers, these were used to classify the CSF samples as either "clean" or "infected" according to the IDSA 2017 guidelines. These classification flags were then integrated with the sensor data, which had been reduced from approximately 4.8 million raw readings to 2750 hourly aggregated data points.

Following preprocessing, the final dataset comprised 2750 rows with 1573 (57.2%) rows available for analysis, after the exclusion of 1177 (42.8%) rows containing missing values in one or more normalized channels. The proportion of available data showed substantial variation across patients, ranging from 18.8% to 76.2% (median 64.2%, IQR 52%–72.4%). Missing data patterns were relatively consistent across all 4 channels (R, G, B, and C), with individual channel missing rates typically ranging between 15% and 38% (median 27.2%, IQR 20.7%–31.8%). One notable outlier was patient 7, who experienced an unusually high rate of missing data (81.2% overall), with the red channel particularly affected (79.7% missing) due to a wire disconnection.

The subspace KNN ensemble reached an accuracy of 91.2% (95% CI 87.0%–94.2%). The final model achieved a

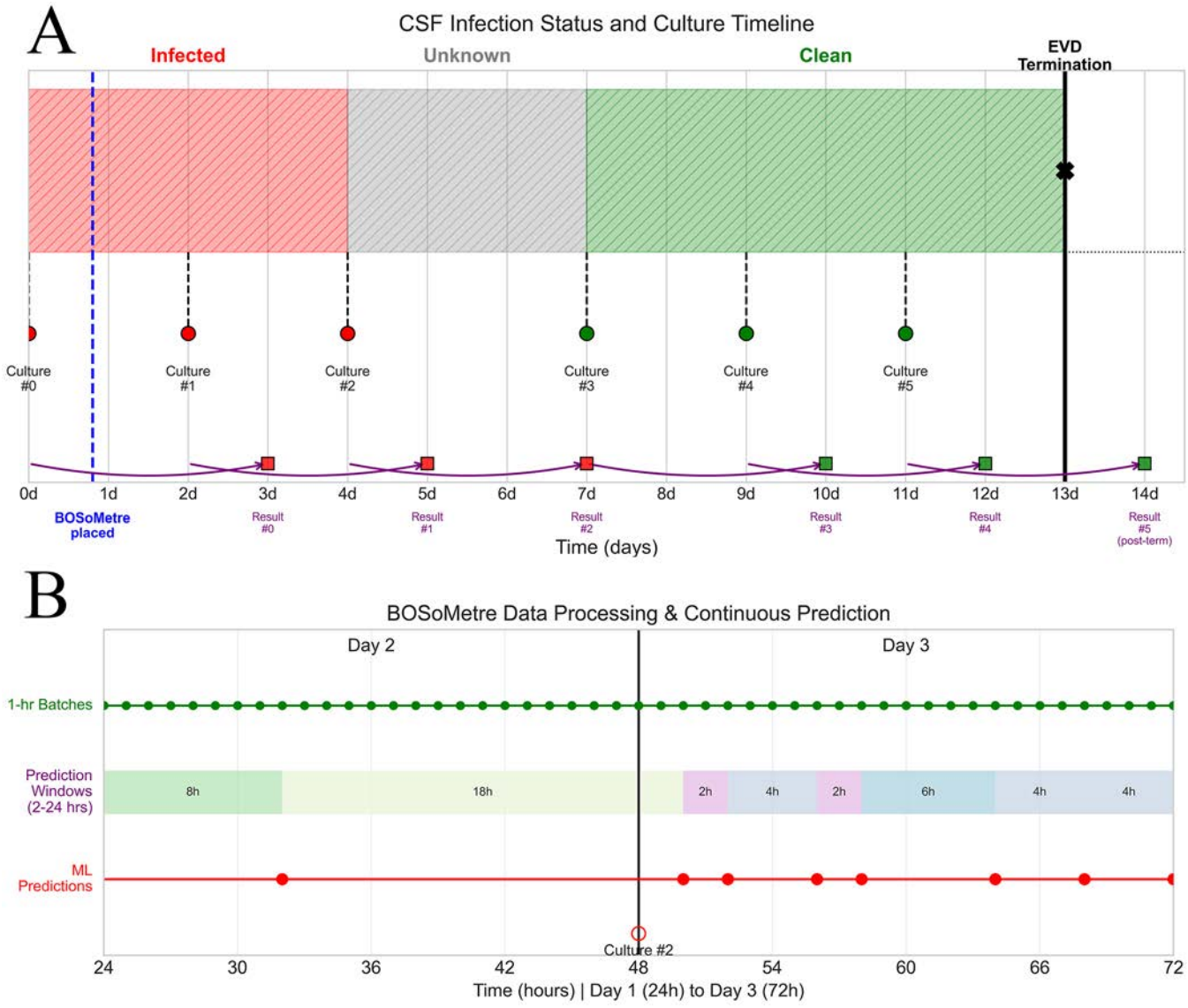

FIG. 3. Timeline comparison of BOSoMetre predictions and CSF culture results. **A:** Overview of a hypothetical patient's clinical course after EVD placement for CSF infection. CSF cultures are obtained at regular intervals (*circles*), with results (*squares*) typically available after 72–96 hours. BOSoMetre is initiated within the first 24 hours to monitor CSF optical properties continuously. *Red zones* indicate periods flagged as infected by the model, *green zones* represent noninfected periods, and *gray zones* mark intervals between two discordant CSF culture results, during which ground truth classification is uncertain. **B:** Zoomed-in view of the 24- to 72-hour period. Machine learning predictions are generated using rolling windows (ranging from 2 to 24 hours), with each window labeled on the basis of the majority of the votes of its internal infection flags. These predictions appear intermittently over time, offering early insight into infection status before the availability of formal culture results. ML = machine learning. Figure is available in color online only.

sensitivity of 92% (95% CI 85.7%–95.8%) and a specificity of 90.4% (95% CI 84.1%–94.8%). The confusion matrix (Fig. 4A), receiver operating characteristic (ROC) curve (area under the curve [AUC] 0.968) (Fig. 4B), and distribution of prediction scores (Fig. 4C) illustrate the classifier's performance in distinguishing between clean and infected samples.

Hyperparameter optimization yielded a random forest model with 50 trees, a minimum leaf size of 1, a maximum of 20 splits per tree, and 4 predictors per node. The screening threshold was set at 0.47, with the decision threshold optimized to 0.71. This configuration achieved an overall accuracy of 81.1% (95% CI 78.1%–83.9%) with a sensitivity of 71.5% (95% CI 66.4%–76.2%) and a specificity of 89.2% (95% CI 85.8%–92.1%). The confusion matrix analysis revealed 364 true negatives, 44 false positives, 246 true positives, and 98 false negatives (Fig. 5A). The ROC curve (Fig. 5B) and prediction score distribution (Fig. 5C) demonstrated clear class separation. The model achieved F1 scores of 0.8368 and 0.7760 for clean and infected classes, respectively, with false-positive and false-negative rates of 10.8% and 28.5% under the dynamic windowing approach.

TABLE 1. Demographic and clinical characteristics of study population (n = 15)

	Value
Age	
Median (IQR)	10.3 (1.3–16.8) yrs
Range	4 mos to 53 yrs
Sex, n (%)	
Male	9 (60.0)
Female	6 (40.0)
Primary indication, n (%)	
Infection	14 (93.3)
Acute hydrocephalus	1 (6.7)
EVD device type, n (%)	
ArgiFix	9 (60.0)
Hpbio Free Flow	6 (40.0)
Monitoring duration, days	
Median (IQR)	11.0 (7.0–15.0)
Range	2–32
Cultures per patient, no.	
Median (IQR)	7 (6–7)
Range	3–16

Discussion

This proof-of-concept study demonstrates the potential of a novel, low-cost CSF-monitoring device built using readily available electronic components and open-source hardware. While the current prototype utilizes consumer-grade electronics and rapid prototyping techniques, the results suggest that meaningful clinical data can be obtained for infection monitoring even with these basic components.

The innovative aspect of this study lies not just in the device itself, but in the approach of combining continuous colorimetric monitoring with machine learning for CSF infection detection. To our knowledge, this represents the first attempt to predict infection states through continuous optical monitoring of CSF characteristics. While more sophisticated optical analysis systems exist in laboratory settings, our approach brings this capability directly to the patient bedside in a form that can be integrated into existing EVD systems.

The performance metrics achieved, while not exceptional, are particularly noteworthy when compared to current diagnostic standards. Conventional CSF cultures, considered the gold standard, demonstrate a sensitivity of 88% under optimal conditions, dropping to 70% in patients receiving antibiotics and further declining to 59% in patients on antibiotics for more than 24 hours.[4] Our device's performance suggests clinical utility within this context, especially considering its noninvasive nature and continuous monitoring capability.

A key advantage of this system is its accessibility and reproducibility. The total cost breakdown per device is approximately € 89, including € 45 for electronic components (Arduino Micro, TCS3200 sensor, MicroSD module, RTC module, and LCD display), € 11 for the power system (lithium-ion battery, UPS module, and power adapter), and € 33 for manufacturing materials (PCB, ABS filament, wiring, and connectors), plus approximately 12–24 labor hours per device for assembly. While a 3D printer represents an initial investment (ranging from € 175 for a basic Creality Ender-3 to € 800 for the Bambu Lab P1S used in this study), this cost is distributed across multiple devices and other research applications. The per-device cost is quickly offset by the expense of just a few routine CSF cultures.[21] The open-source nature of both hardware designs and software facilitates further development and validation by other research groups, potentially accelerating the path to clinical implementation while minimizing barriers to adoption in resource-limited settings.

However, several significant limitations must be acknowledged. The current prototype's reliability is constrained by the consumer-grade components used, as evidenced by the 42.7% data exclusion rate due to recording inconsistencies. Voltage instability and interdevice variability significantly exceeded what would be acceptable in medical-grade equipment. The necessity to account for different EVD brands introduces additional complexity in standardizing measurements. While acceptable in a proof-of-concept study, these technical issues need to be addressed in any future clinical implementation.

The assembly process itself presents challenges, with individual solder connections potentially compromising entire data channels, as demonstrated by the 79.7% data loss in 1 patient case. While these issues could be resolved through professional manufacturing processes, they highlight the current prototype's limitations.

Furthermore, the device's current implementation as a passive monitoring system, without onboard predictive capabilities, represents a deliberate choice aligned with ethical study constraints rather than a technical limitation. Future iterations could incorporate edge computing capabilities with minimal additional cost, though this would require separate validation studies.

Similarly, the decision to focus on patients with suspected or confirmed CSF infection reflects both clinical practicality and technical feasibility. At our institution, most EVDs placed for noninfectious indications are associated with hemorrhagic conditions, which are less amenable to optical sensing due to the strong light attenuation caused by blood. In our preliminary, unanalyzed data, we observed that blood-contaminated CSF markedly alters sensor readings, potentially masking the optical features associated with infection. Additionally, given that the infection rate in initially sterile EVDs is approximately 10%,[2] identifying new-onset infections would require a substantially larger cohort. Most importantly, this focus aligns with clinical priorities: in current practice, we are primarily concerned with determining when an infection has cleared to proceed with permanent shunt placement. While an early infection detection system would be a valuable future capability, our current goal is to validate the feasibility of real-time monitoring during infection resolution, a more immediate and actionable need in neurosurgical care.

While sufficient for demonstrating proof-of-concept,

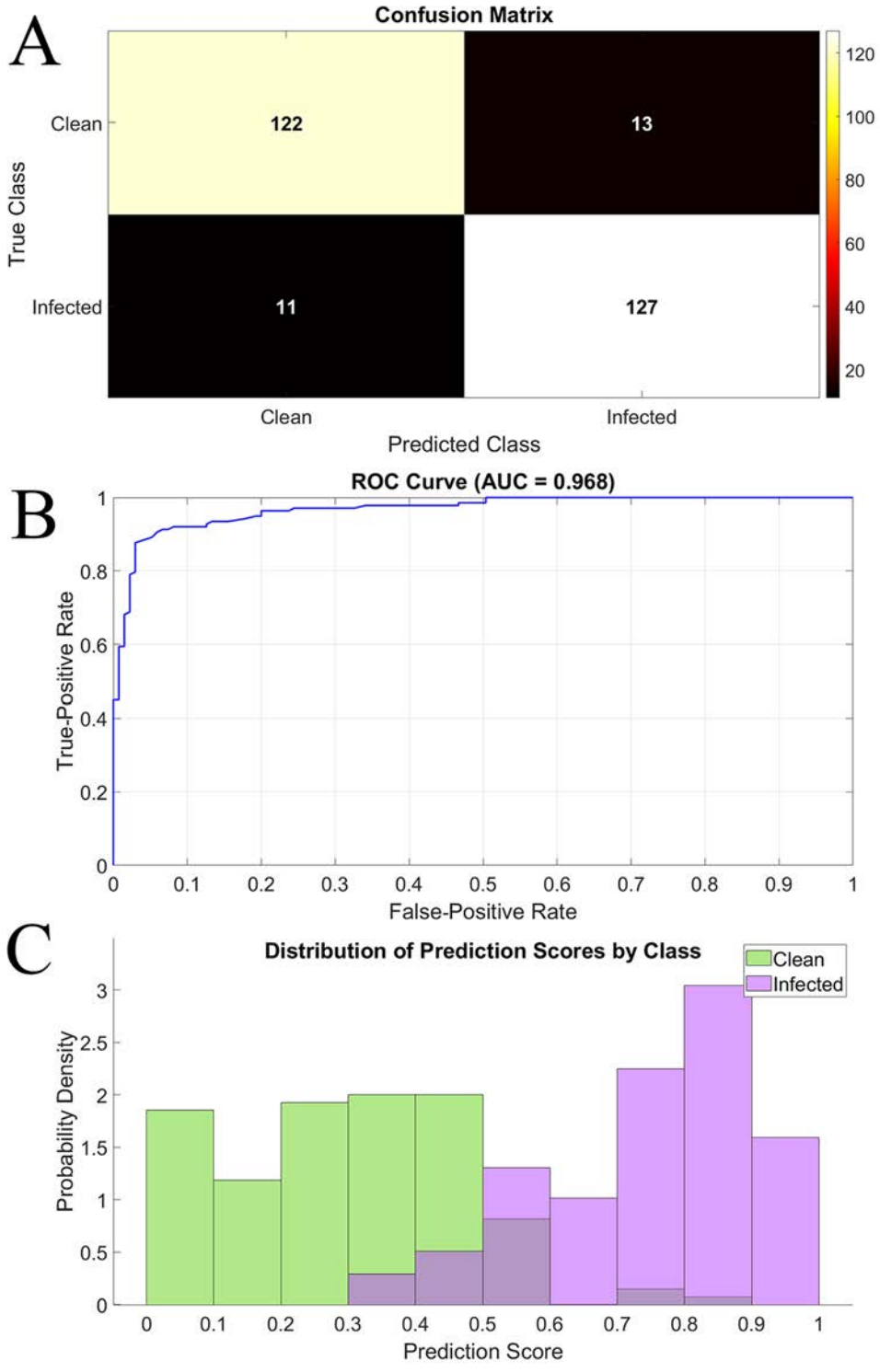

FIG. 4. Subspace KNN model performance metrics for CSF infection classification. **A:** Confusion matrix showing the distribution of true and predicted classifications for clean and infected CSF samples. **B:** ROC curve showing model discrimination performance with an AUC of 0.968. **C:** Distribution of prediction scores by class, illustrating the separation between clean (*green*) and infected (*purple*) sample predictions. Figure is available in color online only.

the current sample size of 15 patients limits the breadth of our conclusions. A larger patient cohort would be necessary to definitively validate the device's clinical utility. The ongoing extension of this study to its planned endpoint of 80 patients (as justified by our initial power analysis) should provide more robust validation of these preliminary findings.

An important and promising aspect of BOSoMetre lies

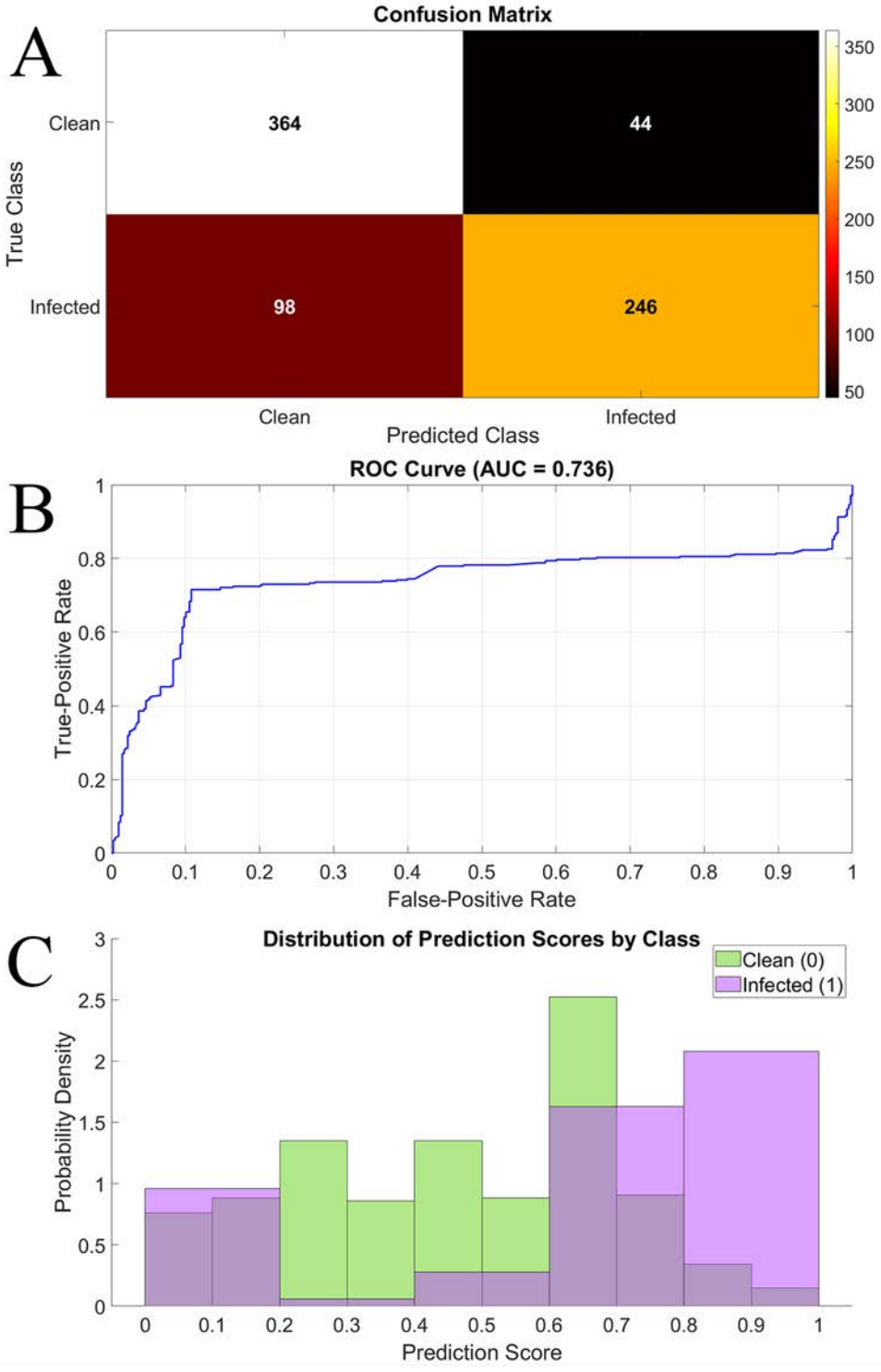

FIG. 5. Random forest model performance metrics with LOOCV. **A:** Confusion matrix showing classification outcomes under the LOOCV framework, with 364 true negatives, 44 false positives, 98 false negatives, and 246 true positives. **B:** ROC curve analysis demonstrating model performance with AUC 0.736. **C:** Distribution of prediction scores separated by class, showing probability density for clean (*green*) and infected (*purple*) samples. Figure is available in color online only.

in its potential to anticipate infection status earlier than conventional CSF culture methods. In our clinical setting, CSF cultures require a minimum of 48 hours for incubation, and results typically become available within 72–96 hours, accounting for human workflow and reporting delays. By contrast, BOSoMetre provides continuous data acquisition and real-time classification using rolling window analysis. Our machine learning pipeline, based on a

random forest model with LOOCV, analyzes aggregated sensor data across 2- to 24-hour intervals and generates infection predictions shortly after the window concludes. This theoretically allows the system to detect changes in CSF characteristics 24–72 hours before standard culture results are available.

However, it is important to note that while BOSoMetre performs well in classifying stable infection or noninfection states, its predictive capacity during transitional episodes, such as the onset or resolution of infection, remains less certain. These transitions are underrepresented in our current dataset and require further enrichment before reliable temporal validation can be claimed. As such, although our findings suggest a significant lead time over microbiological confirmation, we have deliberately refrained from making conclusive statements about early detection. This will be a central focus of the planned analysis once our whole cohort is reached.

The observed data-quality issues merit particular attention. The high proportion of excluded data points (42.7%) reflects both the technical limitations of consumer-grade components and the challenges of maintaining consistent measurements in a clinical setting. While our later implementation of voltage logging and cross-device normalization, introduced after the fourth patient, marked an essential methodological improvement, it was prompted by the lack of baseline voltage measurements and corresponding baseline sensor reading in the early cases. This change improved measurement consistency but highlights that widespread use of such a device will require more rigorous, standardized calibration methods and potentially higher grade components.

The use of multiple EVD brands in our study introduced additional complexity to data interpretation. While baseline calibration compensated for different overall transmission rates, the varying optical properties and manufacturing tolerances of EVD tubing may have caused some unforeseen and inconsistent measurements. Medical-grade PVC tubing is not optimized for optical clarity or uniformity, as these properties are irrelevant to EVD function. This limitation suggests an opportunity for collaboration with EVD manufacturers to develop tubing specifications that would better support optical monitoring.

Notwithstanding these limitations, our results suggest that even basic implementation of continuous optical CSF monitoring can provide clinically relevant information. The device's ability to detect clean samples with high specificity could help optimize sampling schedules, potentially reducing the risk of iatrogenic infections from unnecessary CSF sampling.[2,5] This aspect alone could justify further development and refinement of the technology.

Finally, the open-source nature of this project serves multiple purposes. Beyond fostering reproducibility and collaborative improvement, it provides a foundation for researchers in resource-limited settings to explore similar monitoring approaches. Additionally, the demonstrated feasibility of this approach may encourage medical device manufacturers to develop more sophisticated implementations of optical CSF monitoring, potentially incorporating the principles shown in this proof-of-concept study into existing EVD systems.

Conclusions

This proof-of-concept study demonstrates the feasibility of a low-cost, continuous CSF monitoring system combining colorimetric analysis with machine learning. Despite the limitations of consumer-grade components, BOSoMetre achieved promising performance metrics in detecting CSF infections, with LOOCV analysis showing 81.1% accuracy, 71.5% sensitivity, and 89.2% specificity. These results, while preliminary, suggest potential clinical utility, particularly in resource-limited settings.

The open-source nature of this project, combined with its demonstrated performance, provides a foundation for the future development of more sophisticated CSF monitoring solutions. While technical challenges remain, this study suggests that continuous optical monitoring of CSF characteristics could become a valuable tool in neurosurgical care, potentially reducing the need for frequent CSF sampling and improving early detection of infections.

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Disclosures

Dr. Akbulut reported a patent for 2025/004127 pending.

Author Contributions

Conception and design: all authors. Acquisition of data: Akbulut, Gürses, Bölük. Analysis and interpretation of data: Akbulut, Gürses, Özgül. Drafting the article: Akbulut. Critically revising the article: Özgül, Bölük, Yurtseven, Biçeroğlu. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Akbulut. Statistical analysis: Akbulut, Özgül. Administrative/technical/material support: Yurtseven, Biçeroğlu. Study supervision: Bölük, Yurtseven, Biçeroğlu. Software design: Akbulut. Device manufacturing: Akbulut.

Supplemental Information

Abstract Presentations

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Data Availability

The data and materials supporting the results or analyses presented in the paper are available at https://github.com/AkbulutBB/BOSoMetre.

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Special issue

Development and validation of a cost-effective three-dimensional-printed cervical spine model for endoscopic posterior cervical foraminotomy training: a prospective educational study from Turkey

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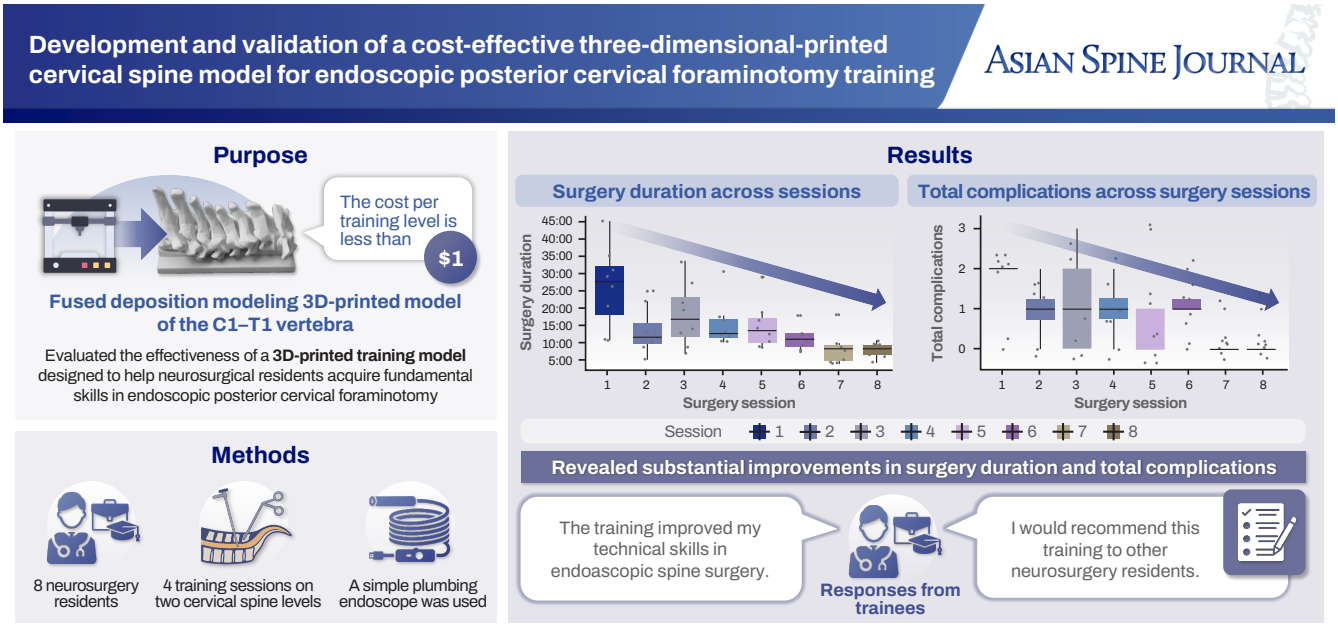

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Development and validation of a cost-effective three-dimensional-printed cervical spine model for endoscopic posterior cervical foraminotomy training: a prospective educational study from Turkey

Bilal Bahadır Akbulut[1,2], Elif Ezgi Çenberlitaş[1], Mustafa Serdar Bölük[1], Taşkın Yurtseven[1], Hüseyin Biçeroğlu[1]

Study Design: Expanding upon established surgical simulation methods, we developed a fused deposition modeling three-dimensional (3D)-printed model of the C1–T1 vertebra for posterior cervical foraminotomy training that features silicone-based neural elements, polyurethane foam-based ligaments, and polyethylene terephthalate glycol vertebrae.

Purpose: This study evaluated the effectiveness of a cost-efficient 3D-printed training model designed to help neurosurgical residents acquire fundamental skills in endoscopic posterior cervical foraminotomy while addressing the technique's challenging learning curve and limited training resources.

Overview of Literature: Only a few studies have investigated the efficacy of such a model.

Methods: Eight neurosurgery residents each with over 2 years of training completed four training sessions on two randomly assigned cervical spine levels using the newly developed 3D-printed model. A simple plumbing endoscope was used for real-time surgical visualization.

Results: Among the 64 completed surgical levels, left-sided procedures showed significantly higher insufficient decompression rates than did right-sided procedures (25.0% vs. 3.6%, p=0.002). However, no significant difference in overall complication rates was observed between sides (p=0.073). Surgical parameters remained consistent across sides, with no significant differences in operative duration. Brunner-Langer analysis revealed substantial improvements in operative duration (mean duration decrease from 21:42±2:15 to 6:33±0:42 minutes, p=0.004) and total complications (mean decrease from 2.1±0.8 to 0.4±0.5, p=0.007) across sessions. Although fluoroscopy timing showed marginal improvement (mean duration decrease from 2:12±1:15 to 0:55±0:23 minutes, p=0.057), the number of fluoroscopic images tended to decrease.

Conclusions: Our findings suggest that this novel 3D-printed cervical spine model could be a viable, low-cost option for neurosurgical training programs aiming to help residents develop essential endoscopic skills in a controlled setting. Facilitating early proficiency in posterior cervical foraminotomy can serve as a valuable intermediate step before transitioning to cadaveric models and clinical practice.

Keywords: Endoscopes; Residency; Minimally invasive surgical procedures; Three-dimensional printing; Simulation training

Introduction

Endoscopic posterior cervical foraminotomy has garnered increasing attention as a minimally invasive technique that somewhat reduced infection rates and decreased postoperative pain compared to conventional microsurgical approaches [1-5]. Despite these benefits, the procedure has a shallow learning curve, necessitating substantial hands-on experience to mitigate potential complications, such as root palsy, dural tears, and iatrogenic instability [4,6-10].

Evidently, this outstanding technique requires thorough training, yet access to comprehensive educational resources remains limited, particularly in low- and middle-income countries. Traditional training modalities, including cadaveric dissections and high-end commercial simulators, can be cost prohibitive and are often subject to ethical and logistical barriers [11-13]. These constraints hinder the widespread adoption of endoscopic procedures and impede the democratization of neurosurgical education.

In response, alternatives such as three-dimensional (3D)-printed models and virtual reality (VR) simulators have gained traction given their cost-effectiveness and ease of dissemination [14-20]. Although VR solutions bypass many logistical hurdles, they cannot replicate the tactile feedback inherent to physical training models. In contrast, 3D-printed simulators can be produced inexpensively, with none of the ethical concerns associated with animal or cadaveric use, while still providing hands-on experience in surgical anatomy and instrumentation.

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To address these challenges, we developed a fused deposition modeling (FDM) 3D-printed cervical spine model to help neurosurgery trainees understand the fundamentals of endoscopic posterior cervical foraminotomy. Using readily available materials and a straightforward design, we aimed to create a realistic yet highly affordable model that could serve as an intermediary step before transitioning to more advanced and costly simulation tools. The current study evaluated the effectiveness of our novel simulator in facilitating early skill acquisition among neurosurgery residents.

Materials and Methods

Ethical standards and participant consent

This study adhered to the ethical principles outlined in the Declaration of Helsinki and had received ethical approval from the Institutional Review Board of Ege University (decision no., 24-4.1T/17; date: April 25, 2024), ensuring that all research involving human subjects was conducted following internationally recognized ethical standards. Before participating in the study, informed consent was obtained from all neurosurgery residents.

Vertebra model preparation

Using spine model files licensed under the Creative Commons Attribution-Share Alike 2.1 Japan license [21], we developed a 3D model spanning from C1 to T1. The model incorporates a silicone-based spinal cord and roots, as well as a polyurethane foam expanding foam to simulate soft tissue structures. Meshmixer ver. 35.0 (Autodesk, San Francisco, CA, USA) was used to modify the vertebra and add a baseplate, whereas Autodesk Fusion ver. 2.0.x (Autodesk) was employed to create the mold for the dura, roots, and skin, along with a rigid box to serve as a waterproof container and dark chamber.

The final model was printed on a P1S FDM printer (Bambu Lab, Shenzhen, China) using three walls, a 0.2-mm layer height, 30% adaptive infill, and four top layers. To ensure consistency, all models used in the study were printed according to these specifications. Additional printing details and relevant files are available in our online repository (https://github.com/AkbulutBB/cervicalendoscope).

Soft tissue preparation

A silicone mold was prepared for the spinal cord and nerve roots using Fusion 360 (https://www.autodesk.com/), with a separate mold created for the "skin." This skin features two slit openings where instruments could be introduced, overlying the dark chamber. Room-temperature-vulcanizing silicone with a Shore hardness of 5 was selected for its affordability and suitability in simulating tissue-like properties. Unlike our previous lumbar model wherein the lamina and vertebral body was printed separately [22], the current model was created by printing the C1–T1 vertebrae as a single piece (Fig. 1A). We then threaded the silicone spinal cord through the spinal canal, inserted the roots into their corresponding foramina using forceps (Fig. 1B), and sprayed expanding insulation polyurethane foam to fill the disc space. This foam simulated a protruding disc by pushing the roots posteriorly and then enveloping the roots to mimic the ligamentum flavum. After a 24-hour curing period, any foam that expanded beyond the lamina was trimmed with a snap-blade knife, subsequently exposing the lamina and the facets (Fig. 1C).

Training equipment design and setup

We improved upon our previous lumbar model by introducing a sliding mechanism attached to a plastic tub rather than securing the model with screws into plywood (Fig. 2A, B). This adjustment allowed for more efficient switching between trainees and prevented wear on the attachment plate. Given our budget constraints,

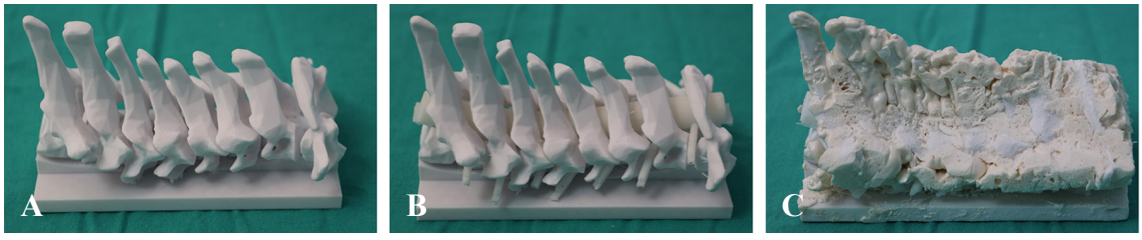

Fig. 1. Three-dimensional (3D) printed cervical spine model assembly stages. **(A)** The raw 3D-printed C1–T1 vertebral model immediately after printing. **(B)** The model after placement of the silicone-based spinal cord and nerve roots; the yellow arrow indicates one of the nerve roots. **(C)** The final state after applying and trimming polyurethane foam, simulating soft tissue and ligamentum flavum.

Fig. 2. The training model housing and setup. **(A)** The dark chamber with sliding mechanism (yellow arrow) and removable lid with gasket (red arrow). **(B)** View showing the cervical spine model being inserted into the sliding track of the chamber. **(C)** The complete setup in surgical configuration, showing the slit openings for instrument access (magenta arrow) and the endoscope with custom handle (green arrow).

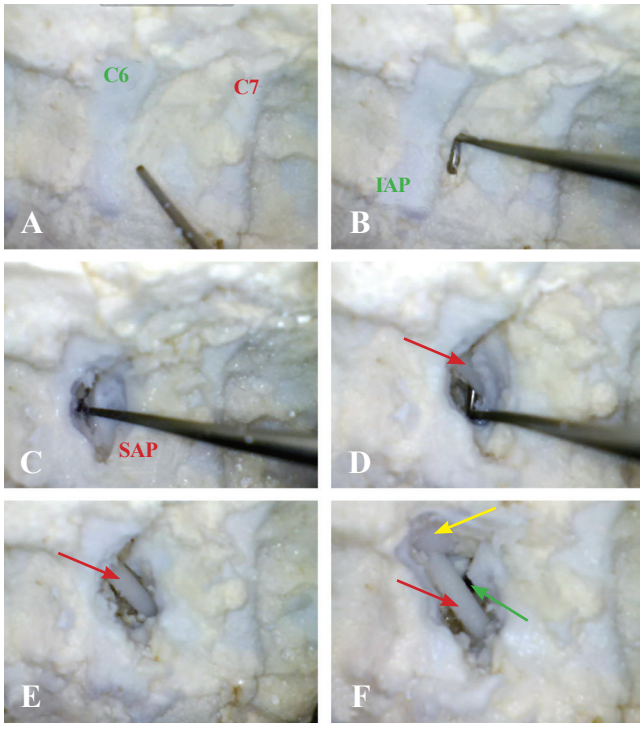

Fig. 3. Endoscopic views captured using the low-cost plumbing endoscope, demonstrating sufficient image quality for training purposes. **(A)** Endoscopic view showing C6 vertebra (green dashed line) and C7 vertebra (red dashed line) with K-wire placement at the facet joint for level localization. **(B)** Surgical hook probing the soft tissue to identify the inferior articular process (IAP) of C6 (outlined in green). **(C)** Visualization after IAP removal reveals the superior articular process (SAP) of C7 (red dashed line) with hook placement for soft tissue mobilization. **(D)** Initial nerve root exposure (red arrow) following partial drilling of the SAP and removal of overlying soft tissue. **(E)** Progressive exposure of the nerve root (red arrow) after additional SAP removal. **(F)** Completed foraminotomy showing the fully decompressed nerve root (red arrow), visible spinal cord (yellow arrow), and exposed disc space (green arrow).

a low-cost plumbing endoscope (Kebidumei, China) was used for visualization (Fig. 2C). Although the quality of this endoscope may not match that of high-end medical equipment, it provided sufficient surgical view for our training purposes and allowed us to keep the overall cost of the model low (Fig. 3). We created a custom polyethylene terephthalate glycol (PETG) handle to house the endoscope and incorporate an irrigation channel compatible with standard intravenous line tubing. Initial trials using a uniportal endoscope design proved unfeasible considering that vibrations from the drill impaired visualization and the specialized surgical tools necessary for that approach were unavailable.

Each newly printed model required approximately 4 hours to print, providing four surgical levels (C3–4, C4–5, C5–6, and C6–7). To account for silicone curing and polyurethane foam setting time, each model required roughly 2 days to prepare and assemble. Switching among residents during the training sessions required less than 5 minutes.

Subject selection and procedure randomization

Residents in their second postgraduate year (PGY 2) were deemed eligible considering that they were capable of taking calls and performing emergency procedures at our clinic. Consequently, eight residents each with over 2 years of training participated in this study. Although all residents were able to perform posterior cervical foraminotomy under supervision, none had previously performed or assisted in endoscopy-assisted posterior cervical foraminotomy. All participating residents were right-handed.

The order of procedures was randomized using the Fisher-Yates shuffle algorithm implemented through the NumPy random.permutation() function (Python ver. 3.x [https://www.python.org/] and NumPy ver. 1.21.0 [https://numpy.org/]) to ensure an unbiased distribution of vertebral levels and operative sides [23,24]. Randomization was organized into blocks of four sessions, each containing two distinct cervical levels and two different sides, thereby standardizing the training intervals and exposure to technique variations.

Training session design

All training sessions were conducted after working hours (18:00 to 20:00) to minimize disruptions and

maintain consistency. The hands-on testing component consisted of three sessions at 1-week intervals to reduce learning decay while allowing adequate rest between sessions. Before the first session, each resident participated in a standardized 30-minute orientation covering the relevant cervical anatomy and radiology in relation to the structures in our 3D-printed model. A pre-operated model was then shown in both plain view and under endoscopic visualization to familiarize the trainees with the silicone nerve roots, simulated dura, polyurethane-based foraminal tissues, and PETG bone structures. This orientation was followed by a 10-minute hands-on exploration, during which the residents practiced manipulating the Midas Rex drill (Medtronic, Dublin, Ireland), Kerrison rongeurs, disc forceps, and a blunt nerve hook under endoscopic guidance.

Once confident with manipulating the endoscope, the residents began the procedure by palpating the spinous processes (starting from C7) to identify the correct level. A Kirschner wire was inserted through the silicone while the research team provided fluoroscopic confirmation (Ziehm Solo fluoroscopy unit; Ziehm Imaging GmbH, Nürnberg, Germany). The attending surgeon recorded the duration from the start of palpation to the final wire placement. The residents were allowed to seek assistance in interpreting the fluoroscopy images or correcting any miscounts of the vertebral levels. Given our emphasis on endoscopic surgical skill rather than fluoroscopic proficiency, necessary help in level identification was provided without penalty.

After confirming the surgical level, the residents introduced the endoscope through the designated opening in the skin overlay, located and removed the Kirschner wire, and then used the Midas Rex drill (Medtronic) to thin the inferior articular process of the superior vertebra and the superior articular process of the inferior vertebra following established protocols. At this step, irrigation was performed using a saline bag connected to the irrigation channel of the endoscope. Once the eggshell thickness of the bone was reached, the residents palpated the space with a blunt hook, mobilized any remaining soft tissue, and removed the bone with 2-mm Kerrison rongeurs to enlarge the surgical corridor. The polyurethane foam meant to mimic the ligamentum flavum was dissected and removed using punch forceps. The trainees concluded the surgery once they believed sufficient bone was removed and the root was fully decompressed, making user to confirm that the hook could be inserted comfortably into the neural foramen and that the margins of the pedicles could be palpated.

Following each session, the attending surgeon reviewed the model in the endoscopic view and then examined the model outside the dark chamber with the trainee, offering visual and tactile feedback on bone removal adequacy and overall technique. Residents also completed a Likert scale questionnaire to evaluate the model's educational value.

Assessment of the surgery

Operative times, the number of fluoroscopic checks, and the duration of fluoroscopy use were documented. Operative time was analyzed separately from fluoroscopic time. Decompression was deemed successful if less than 50% of the facet joint was removed, the nerve root was fully mobilized, a nerve hook could pass smoothly through the foramen, and the margins of the pedicles could be palpated. Excessive bone removal (over 50% of the facet) and root injury (e.g., transection or avulsion) were also recorded. These four key parameters, namely excessive bone removal, root injury, wrong-level surgery, and incomplete decompression, were aggregated into a 4-point score, with 0 signifying a perfect score and 4 representing the most severe outcome.

During Kirschner wire placement, the research team provided radiological assistance to ensure that the correct level was targeted. However, if a resident ultimately performed the procedure on an unintended level (e.g., operating at C5–6 left instead of the planned C4–5 left), the session was documented according to the actual level treated. The originally intended level was then reassigned to a future session, ensuring that each resident still gained experience at every designated level.

Statistical analysis

Analyses were conducted using R software ver. 4.4.2 (R Foundation for Statistical Computing, Vienna, Austria) and IBM SPSS ver. 27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated in SPSS, with the results being presented as means and standard deviations for normally distributed variables and medians and interquartile ranges for variables not following normal distributions. For all analyses, statistical significance was set at $p<0.05$.

Our primary statistical approach involved the Brunner-Langer nonparametric analysis (F1-LD model), implemented through the nparLD package in R. This method is particularly well-suited for our study design given that it handles longitudinal data without requiring assumptions of normality or sphericity, making it ideal for small-sample, repeated-measures designs.

We calculated the relative treatment effects (RTEs) for each outcome measure to quantify the magnitude and direction of changes across sessions, with values ranging from 0 to 1, where 0.5 represents no effect. Notably, values above 0.5 indicate higher ranks (generally poorer performance), whereas those below 0.5 indicate lower ranks (typically better performance) relative to the overall distribution of measurements.

Results

Eight neurosurgical residents (five PGY-3, one PGY-4, and two PGY-5) performed a total of 64 procedures, with each resident completing surgeries on all cervical levels from C3–4 to C6–7 distributed equally between the right and left sides.

The most striking finding was the marked disparity in insufficient decompression rates between the sides, with left-sided procedures showing significantly higher rates than did right-sided procedures (25.0% versus 3.6%, p=0.002). Although right-sided procedures tended to have better outcomes than did left-sided procedures, with 57.1% and 35.7% of right- and left-sided procedures having no complications, this difference in overall complication rates did not reach statistical significance (p=0.073).

Surgical metrics showed remarkable consistency across several parameters. No significant differences in operative duration (right: 15:58±9:50 minutes versus left: 13:46±7:47 minutes, p=0.358) or fluoroscopy timing (right: 1:20±0:55 minutes versus left: 1:35±1:04 minutes, p=0.348) were observed between the sides. The number of fluoroscopic images required was also similar between the sides (right: 1.89±1.77 versus left: 2.61±3.51, p=0.341).

Analysis according to cervical level revealed no significant differences in surgical parameters or outcomes. The mean operative times were comparable across all levels (C3–4: 14:25±8:25 minutes; C4–5: 15:14±8:04 minutes; C5–6: 13:35±9:12 minutes; and C6–7: 14:45±9:36 minutes; p=0.961). Similarly, the fluoroscopy requirements showed no level-specific variations in either duration (p=0.977) or number of images (p=0.979). Complication rates, including insufficient decompression (p=0.487), were consistent across all cervical levels.

Time to fluoroscopy improved across sessions, although with marginal statistical significance (analysis of variance [ANOVA]-type test statistic=2.83, degrees of freedom [df]=3.30, p=0.057). The RTEs demonstrated inconsistent patterns of improvement, with some early sessions showing higher values (Time1: RTE=0.70; Time3: RTE=0.73) compared to later sessions (Time4: RTE=0.33; Time8: RTE=0.35) (Fig. 4).

Operative duration significantly improved across sessions (ANOVA-type test statistic=5.99, df=3.10, p=0.004). The initial sessions had notably higher RTEs (Time1: RTE=0.81), with a marked and consistent de-

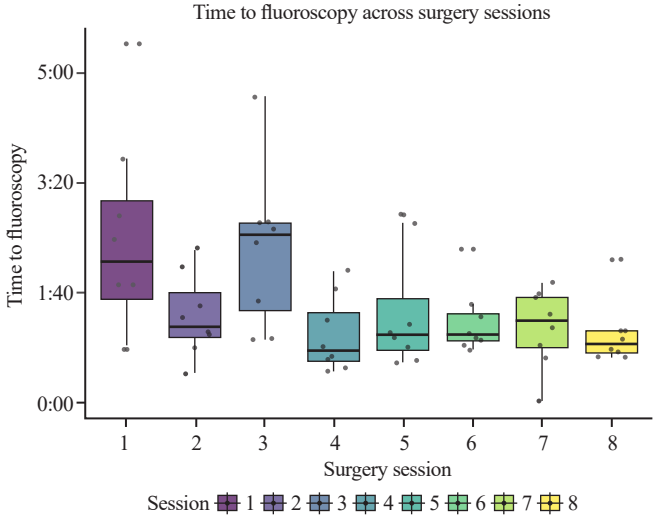

Fig. 4. Box plot showing the time (in minutes) taken to achieve correct fluoroscopic localization across eight surgical sessions. Each point represents an individual procedure, with box plots displaying each session's median, quartiles, and range. The gradual color transition from purple to yellow represents the progression of sessions from 1 to 8. A trend toward decreased fluoroscopy time is observed across successive sessions, with median times decreasing from approximately 2 minutes in early sessions to under 1 minute in later sessions, though with notable variability between procedures.

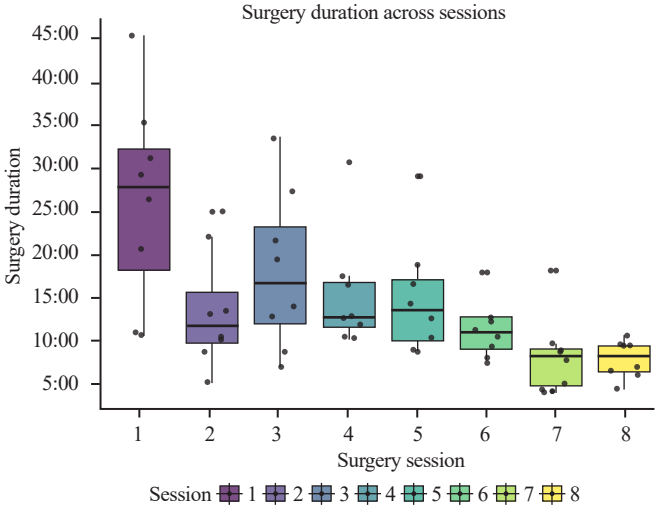

Fig. 5. Box plot demonstrating the progressive reduction in surgical duration (in minutes) across eight training sessions. Each data point represents an individual procedure, with box plots showing each session's median, quartiles, and range. The color gradient from purple (session 1) to yellow (session 8) tracks the chronological progression. A clear trend of decreasing operative times is observed, with median durations reducing from approximately 28 minutes in session 1 to under 10 minutes by session 8 (p=0.004), indicating significant improvement in surgical efficiency with practice.

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crease observed in later sessions (Time7: RTE=0.23; Time8: RTE=0.22) (Figs. 5, 6).

Significant changes in total complications were observed across sessions (ANOVA-type test statistic=4.74, df=3.52, p=0.007). RTE revealed a substantial decrease in complications from early sessions (Time1: RTE=0.77) to later sessions (Time7 and Time8: both RTE=0.26) (Fig. 7).

The number of fluoroscopy images tended to improve, though not reaching statistical significance (ANOVA-type test statistic=2.36, df=3.54, p=0.088). Early sessions required more imaging (Time1–3: RTEs approximately 0.62–0.63), whereas later sessions showed reduced reliance on fluoroscopy (Time8: RTE=0.35).

Resident feedback demonstrated high satisfaction with the educational value of the model, particularly regarding improvements in surgical technique and overall confidence in endoscopic procedures (Fig. 8). However, the participants consistently noted that the low-cost plumbing endoscope used in the study presented some practical challenges, specifically poor image quality and

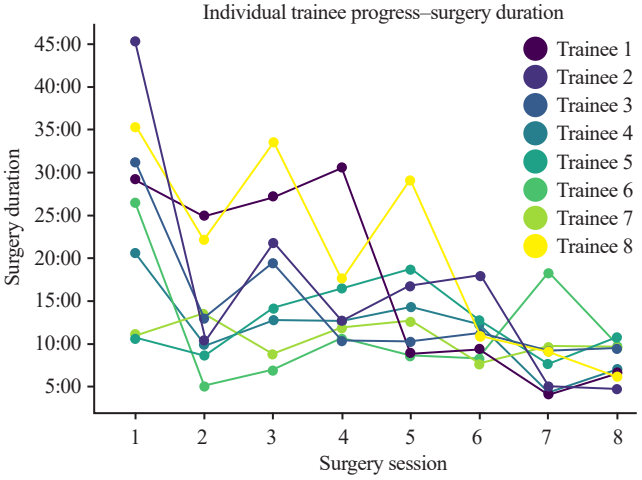

Fig. 6. Line graph showing individual learning curves for each trainee's surgical duration (in minutes) across eight sessions. Each colored line represents a different trainee's progression. While initial performance varied considerably (ranging from approximately 10 to 45 minutes), all trainees demonstrated substantial improvement and converged toward more consistent, shorter operative times (5–10 minutes) by the final sessions, suggesting successful skill acquisition regardless of starting performance.

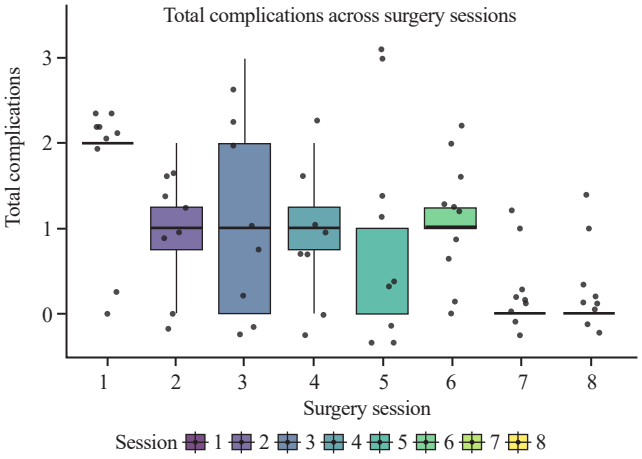

Fig. 7. Box plot depicting the total number of complications per procedure across eight training sessions. Each point represents an individual procedure, with box plots showing the median, quartiles, and range. A significant reduction in complications is observed from early sessions (median of 2 complications) to later sessions (median of 0 complications) (p=0.007). The color progression from purple to yellow represents chronological session order, with later sessions showing lower median values and reduced variability in complication rates.

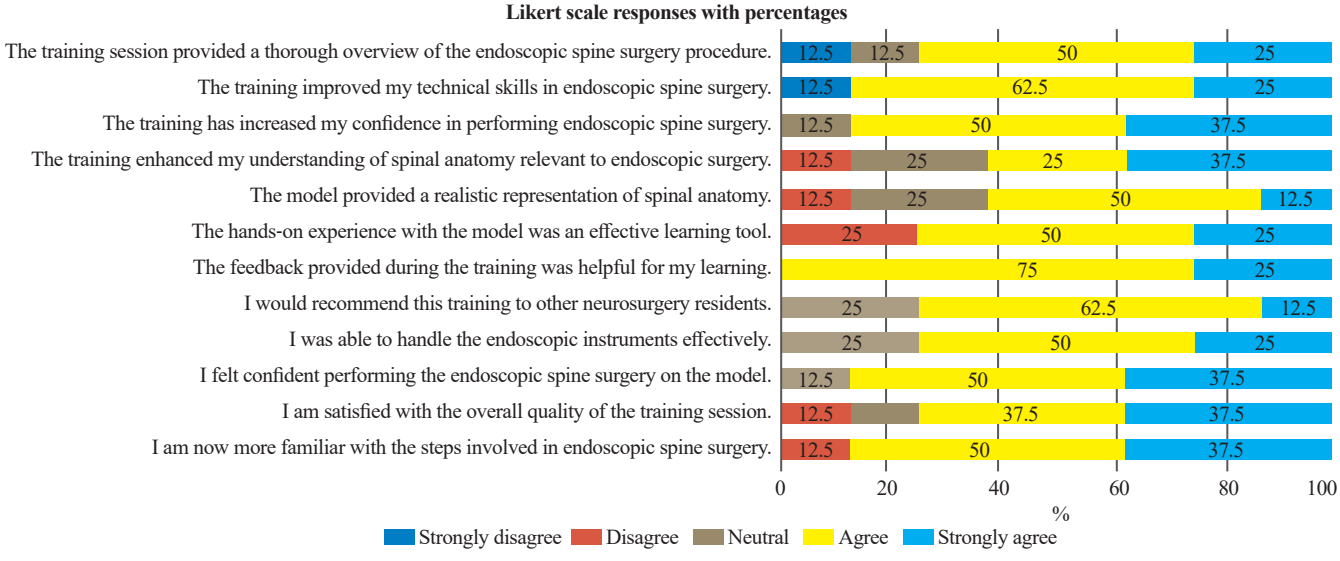

Fig. 8. This figure presents the distribution of responses from trainees (n=8) to a 12-item Likert-scale questionnaire evaluating the training. Each horizontal bar represents a single survey question, with the five response options displayed as stacked segments. The percentages corresponding to each category are shown on the bars.

frequent lens fogging that required periodic cleaning with a gauze. Despite these technical limitations, an intentional trade-off to maintain the model's affordability, the residents still regarded the training experience as highly beneficial for developing fundamental surgical skills (detailed feedback data available in the Supplement 1).

Discussion

The current study assessed the effectiveness of a novel, cost-effective 3D-printed cervical spine model for endoscopic posterior cervical foraminotomy training. Our findings demonstrate that this model reduces operative time and complication rates and provides a safe, controlled environment for residents to hone their skills. This model, similar to the endoscopic lumbar surgery simulator developed in our previous research [22], stands out for its accessibility and affordability.

One of the primary advantages of our model is its low material cost, which had been achieved by using widely available PETG filament, polyurethane foam, and silicone to replicate essential anatomical features at a fraction of the expense associated with traditional simulators or cadaveric training. This significant cost reduction is particularly beneficial for low-resource settings where economic barriers often limit access to advanced surgical education [11,13]. By releasing the model's design and printing guidelines online, we are democratizing neurosurgical education, ensuring that any institution equipped with a standard 3D printer can reproduce our cervical spine simulator. This open-source principle ensures that the benefits of our model, namely its affordability, accessibility, and educational impact, can be broadly shared rather than restricted to high-cost commercial solutions.

An itemized examination of material usage underscores the economic feasibility of our model. The dark box, molds, and handle collectively require around 1,000 g of PETG filament at $17.14/kg (approximately $17.14 in total) and are reusable across multiple sessions. The main silicone "skin" (600 g at $10.97/kg) costs around $6.58 and is also reusable for several training cycles. In contrast, the truly single-use components include the silicone cord (20 g at $0.22 each), the PETG-printed cervical model (85 g at $1.46 each), and the polyurethane foam (60 g at $0.36 per application). These consumables cost approximately $2.04 per new model, providing eight cervical training levels at roughly $0.26 per surgical level. This one-time architecture and low-cost consumables maximize affordability while preserving the tactile and visual realism that novice surgeons require for endoscopic posterior cervical foraminotomy. Although the initial purchase of a 3D printer can be a notable expense, with our study utilizing a Bambu Lab P1S ($800), the same models can also be reliably produced on more budget-friendly devices, such as the Creality Ender-3 S1 ($175).

Aside from its cost-effectiveness, our model aligns with the ethical standards in surgical education. We address the moral complexities and logistical constraints of traditional training methods by offering a realistic simulator that does not require animal or human cadaveric specimens [12,25,26]. Our 3D-printed model provides a practical and ethically sound alternative to animal models and cadaveric studies, which often face sourcing, preservation, and ethical consent issues. Moreover, unlike many augmented or VR platforms [14-18], which can be prohibitively expensive and usually lack robust haptic feedback, our tangible model enables hands-on practice of drilling, nerve retraction, and foraminotomy in a setting that closely mimics real surgical conditions.

A notable finding of our study was the marked disparity in decompression adequacy between surgical sides, with left-sided procedures showing significantly higher rates of insufficient decompression than did right-sided procedures (31.3% versus 3.1%, p=0.003). This laterality effect may be attributed to two factors. First, the posterior–inferior trajectory required for left-sided bone removal with the Kerrison rongeur creates an awkward working angle for right-handed surgeons, potentially compromising the precision and extent of decompression. Second, visualization of the ipsilateral surgical field demands an unintuitive hand position, similar to the challenges in identifying residual disc material during anterior cervical discectomy and fusion procedures. Although our literature review identified only one retrospective single-surgeon series that reported no significant differences between sides [27], our findings suggest that side-specific technical challenges may be particularly relevant during the learning phase of endoscopic procedures. Several strategies could mitigate these laterality-related challenges. Integrating surgical navigation systems early during training could provide real-time feedback on instrument positioning and decompression adequacy. Alternatively, modifying the operative approach by positioning the surgeon on the right side of the patient during the surgical treatment of left-sided pathology might create more ergonomic working angles. Moreover, incorporating downward-cutting Kerrison rongeurs, rather than solely

relying on standard upward-cutting instruments, could improve instrument handling during left-sided procedures. Future research should systematically evaluate these potential solutions, particularly by analyzing early outcomes from experienced training centers, to determine whether this laterality effect persists beyond the learning curve or can be effectively addressed through specific technical modifications.

Similar to our lumbar endoscopy model and previously published models, the current model cannot simulate certain complexities of live surgery, such as active bleeding, muscle tissue, and dynamic tissue responses [19,22,28,29]. Likewise, the model fails to accommodate all potential anatomical variability or fully simulate water inflow or the nuanced sensation of human bone under a high-speed drill. Hence, despite being an invaluable stepping stone, the simulator should be complemented by higher-fidelity training modalities, such as cadaver labs, advanced VR systems, or ultimately supervised live surgeries.

Another area for improvement is the sample size and generalizability of our study. As with any pilot study, our participant pool was limited to a modest number of residents affiliated with a single institution. Although our power analysis and effect sizes indicated robust improvements in operative times, future research should involve larger cohorts and diverse training environments to better capture variability in skill acquisition and affirm our findings' external validity. Furthermore, despite having tracked parameters such as fluoroscopy use and operative times, objective measures of complication risk, especially dural tears or nerve root injuries, remain challenging to simulate. This shortcoming underscores the need for continued research and development in surgical simulation.

Another vital consideration for simulating iatrogenic trauma is the choice of the soft-tissue analog. Our lumbar discectomy model used thermoplastic polyurethane (TPU) filaments for the dura and nerve roots, allowing the paint layers to peel off with tool mismanagement and reveal the extent of damage [22]. For the cervical model, we opted for silicone to more faithfully replicate the cord and root structures. In thin, delicate segments (roots with a diameter of 3 mm), silicone more closely approximates the elasticity and tactile sensation of the cervical anatomy than does TPU. However, silicone is famously nonadhesive, consequently preventing the application of the paint layers designed to peel and reveal microtrauma, as had been done previously. In practice, however, the smooth surface of silicone makes cuts and defects visually obvious, reducing the need for paint layers. Regardless, the lack of a paint-peel metric hinders the precise quantification of minor surface abrasions. Future refinements could explore other forms of surface treatments to more systematically simulate dural or nerve injury.

Despite these constraints, the model offers an innovative, replicable framework for initial training in endoscopic posterior cervical foraminotomy. Participants found the simulator realistic enough to build confidence in surgical ergonomics, drill handling, and endoscopic visualization, skills that can be transferable to higher-fidelity training or clinical practice once established. From an institutional standpoint, the low cost and ease of printing make our model suitable for repeated, iterative practice sessions. This architecture is particularly beneficial for novice residents who often require extended hands-on exposure before developing proficiency in delicate endoscopic procedures.

Our 3D-printed model also has substantial potential for expansion beyond its current application. The system could be readily adapted for more complex procedures, such as cervical decompression or laminoplasty, by maintaining the same baseplate and dark chamber structure. One promising avenue involves incorporating patient-specific anatomical variations by converting DICOM images from real patients with foraminal or central stenosis into printable 3D models and integrating these into our baseplate design, a process that typically requires less than a day to complete. To further democratize neurosurgical education, these models could utilize anonymized cases from open repositories, such as the DICOM Library, funded by the European Union, allowing free sharing across training institutions worldwide. Integration into augmented reality represents another compelling frontier, enabling trainees to visualize tool and camera positioning in real-time when combined with navigation systems. Such a technology could enhance spatial awareness during procedures or more comprehensively simulate the operating room environment. Although these advanced applications exceed the current scope of our study, they offer perspectives for future collaborative research efforts aimed at further reducing barriers to high-quality endoscopic spine surgery training.

Conclusions

Our 3D-printed cervical spine simulator represents another step toward our broader initiative to democratize neurosurgical education. Much like our previously reported model for lumbar endoscopic surgery, this cer-

vical platform underscores the feasibility of combining open-source 3D printing technology, inexpensive materials, and carefully engineered designs to produce a practical training solution. Although our model cannot simulate the complexity and variability of live surgery, it is a powerful adjunct for bridging the gap between theoretical knowledge and high-fidelity surgical practice, ultimately enhancing the confidence and competence of neurosurgery trainees.

Key Points

- The materials needed to construct this innovative three-dimensional-printed spine model cost less than $1 per training level, making it highly affordable.
- The use of the model significantly improved surgical efficiency, with mean operative durations decreasing from 21:42±2:15 to 6:33±0:42 minutes across training sessions.
- The model effectively simulates tissue handling using silicone-based neural elements, polyurethane foam-based ligaments, and polyethylene terephthalate glycol vertebrae, providing residents with realistic tactile feedback.
- This accessible and cost-effective alternative to cadaveric training significantly reduced complication rates across sessions (from 2.1±0.8 to 0.4±0.5), making it suitable for various resource settings.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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The data supporting this study's findings are available in the supplementary files.

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Supplementary Materials

Supplementary materials can be available from https://doi.org/10.31616/2025.0050. Supplement 1. Likert scale questionnaire answers of the residents and their surgery data.

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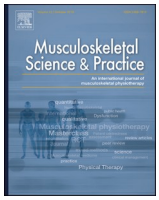

Original article

Pain intensity, spine structure, and body composition in patients with acute discogenic lumbar radiculopathy

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ABSTRACT

Objective: This study aimed to compare the pain intensity, spine structure, and body composition according to functional disability levels in patients with acute discogenic lumbar radiculopathy (DLR).
Methods: A total of 118 women (n = 83) and men (n = 35) patients with acute DLR (mean age: 51.87 ± 13.38 years) were included in the study. The function ability was measured with the Oswestry Disability Index, pain intensity was measured with the Visual Analogue Scale, spine structure was measured with the Spinal Mouse® device, and body composition was measured with the Bioelectrical Impedance Analysis System.
Results: Patients with mild functional disability levels had significantly lower activity (p<.001) and night pain intensity (p = 0.001) than patients with moderate, severe, and completely functional disability levels, and patients with completely functional disability levels had significantly higher rest pain intensity (p = 0.005) than patients with mild, moderate, and severe functional disability levels. Patients with mild functional disability levels had significantly better spine check scores (p = 0.001), posture (p = 0.005), and mobility (p = 0.003) than patients with moderate, severe, and completely functional disability levels. Patients with mild functional disability levels had significantly lower fat percentage (p = 0.032), and higher basal metabolic rate (p = 0.024) than patients with moderate, severe, and completely functional disability levels.
Conclusion: Pain intensity, spinal structure, and body composition of acute DLR patients differ greatly according to their functional disability levels. Although it is known that the level of functional disability of patients is a result of the severity or prognosis of the disease, performing different treatment methods aimed at decreasing the functional disability level of patients by health professionals may be important in terms of coping with the disease.

1. Introduction

Low back pain (LBP) is one of the most common disorders in the general population, generating pain, disability, and psychosocial or socioeconomic consequences (Ramond-Roquin et al., 2015). The point prevalence and the 1-month prevalence of LBP in the general population are estimated to be 11.9% and 23%, respectively (Hoy et al., 2012). It is reported that approximately 60%–80% of individuals suffer from LBP at least once in their life span (Balthazard et al., 2012). Furthermore, it generates enormous direct costs such as health care consumption, medication, and medical imaging and indirect costs such as work absenteeism for society (Becker et al., 2010).

Although it is generally known that LBP is non-specific, lumbar disc herniation (LDH) is one of the most important causes of LBP (Braun et al., 2014). Approximately 80% of the structures responsible for LBP are related to the intervertebral discs and may be accompanied by radicular symptoms (Choi et al., 2015; Braun et al., 2014). This radiating pain is known as discogenic lumbar radiculopathy (DLR) which is caused by the compression of lumbar spinal nerve roots (Amjad et al., 2022). Annual prevalence of DLR varies between 2% and 34%, possibly

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due to differences in the interpretation of clinical symptoms and signs, and affects more men than women (2:1) (Konstantinou and Dunn, 2008; Manek and MacGregor, 2005; Schoenfeld et al., 2012). The overall DLR is estimated at 4.8 per 1000 person-years (Ahmed et al., 2022b). Nowadays, DLR is one of the leading causes of functional limitations or disabilities worldwide (Chew et al., 2022). Furthermore, the functional disability related to DLR are expected to increase in the coming decades with industrialization and/or physical inactivity (Hartvigsen et al., 2018). On the other hand, the pain intensity may vary depending on the level of pathological and/or degenerative changes occurring in the intervertebral discs and the resulting compression of the lumbar spinal nerve roots.

The vertebral column is an important mechanical structure in dynamic equilibrium in healthy individuals and is maintained by a combination of structures, innervated by both mechanoceptors and nociceptors (Mehta et al., 2022). With the degenerative processes, spine structures results in irreversible chronic neural irritation. Also, the normal lordosis of the lumbar vertebrae and the wedge-shaped disks produce the angulation between the fifth lumbar vertebra and the sacrum, and traumatic and atraumatic problems between L5 and S1 are relatively common. As a result of the inclination of the superior surface of S1, L5 tends to slide inferiorly and anteriorly in the setting of spondylolysis. Lumbar nerve radiculopathy or DLR, which can occur at different levels in the lumbar region, frequently occurs due to spondylosis and spondylolisthesis, especially at the L5-S1 level. On the other hand, it has been reported that the increase in pro-inflammatory cytokines produced by hypertrophic adipose tissue is partially responsible for the increase in the prevalence of LBP in obese patients, in addition to increasing the mechanical stress caused by excess weight (da Cruz Fernandes et al., 2018). Moreover, mechanical stress caused by excess weight can negatively affect the alignment and biomechanics of the spine. Furthermore, it has been emphasized that there is a relationship between low back pain and body composition (Tarabeih et al., 2022a; Tarabeih et al., 2022b). Therefore, spine structure and body composition are an important parameters that should be investigated in patients with DLR.

Previous studies on DLR have primarily examined the effects of different treatment methods on functional disability and pain in these patients (Amjad et al., 2022; Rehman et al., 2022; Ahmed et al., 2022a). Moreover, it was concluded that the body composition and spinal structures of these patients were not sufficiently focused on. However, the functional disability seen in patients with DLR may cause an increase in pain intensity, worsening body composition, and therefore negative biomechanical changes in the spine structure. Moreover, the pain intensity, body composition and spine structure involvement may differ in patients with DLR according to different levels of functional disability. Therefore, this study aimed to compare the pain intensity, spine structure, and body composition according to functional disability levels in patients with acute DLR. We hypothesized that pain intensity, spine structure, and body composition would worsen with functional disability in patients with acute DLR.

Fig. 1. Spine structure assessment with the Spinal Mouse.

2. Methods

2.1. Design and aspect of the study

The present study which was planned as a cross-sectional study was carried out at Izmir Katip Celebi University Physiotherapy and Rehabilitation Application and Research Center in December. The study protocol was approved by the Izmir Katip Celebi University Non-Interventional Clinical Studies Ethics Committee (Approval Number: 0543). The study was conducted in accordance with the principles of the Declaration of Helsinki. A written informed consent was obtained from the participants. Also, all participants were informed about the aims and benefits of the study.

2.2. Participant

A total of 118 women (n = 83) and men (n = 35) patients with acute DLR who were diagnosed with acute DLR by a neurosurgeon, volunteered to participate, and met the inclusion criteria were included in the study. The inclusion criteria for the study were as follows: having symptoms such as functional disability, low back and/or leg pain, numbness, and tingling for less than 4 weeks, radiological findings to be confirmed by magnetic resonance imaging (MRI), a positive score on the Straight Leg Raise test (pain between 35° and 75°), and a restricted lumbar range of motion (25% and 20% reduction in flexion and extension, respectively) (Parker et al., 2010; Ahmed et al., 2022a, 2022b). Also, the exclusion criteria for the study were as follows: having a segmental instability, severe neurological deficit, cognitive dysfunction, spinal compression fracture, spondylolisthesis, and spinal fusion (Koçak et al., 2018; Asafu Adjaye Frimpong et al., 2020).

2.3. Outcome measures

Descriptive characteristics (age, gender, height, and weight) of participants were recorded through face-to-face interviews. Then, participants were divided into 4 groups according to their functional disability levels [mild disability n = 23), moderate disability (n = 39), severe disability (n = 34), and completely disabled (n = 22)]. Pain intensity, spine structure, and body composition were compared according to their functional disability levels.

2.4. Functional disability

The functional disability was assessed with the Oswestry Disability Index (ODI). The ODI is a valid and reliable self-administered questionnaire that is considered the “gold standard” in assessing the functional disability of patients with LBP (Fairbank and Pynsent, 2000). The Turkish validity and reliability study of the index was conducted by Yakut et al., in 2004 (Yakut et al., 2004). It contains ten sections involving pain intensity, personal care, lifting, walking, sitting, standing, sleeping, social life, travelling, employment/homemaking. Each section has six possible answers to be marked on a 0 to 5 points. The lowest score that can be obtained from the index is 0 and the highest score is 50. The higher scores indicate a higher level of functional disability. Scores obtained from the index between 0 and 4, 5 to 14, 15 to 24, 25 to 34, and 35 to 50 are interpreted as “no disability”, “mild disability”, “moderate disability”, “severe disability”, and “completely disabled”, respectively. In addition, the functional disability of

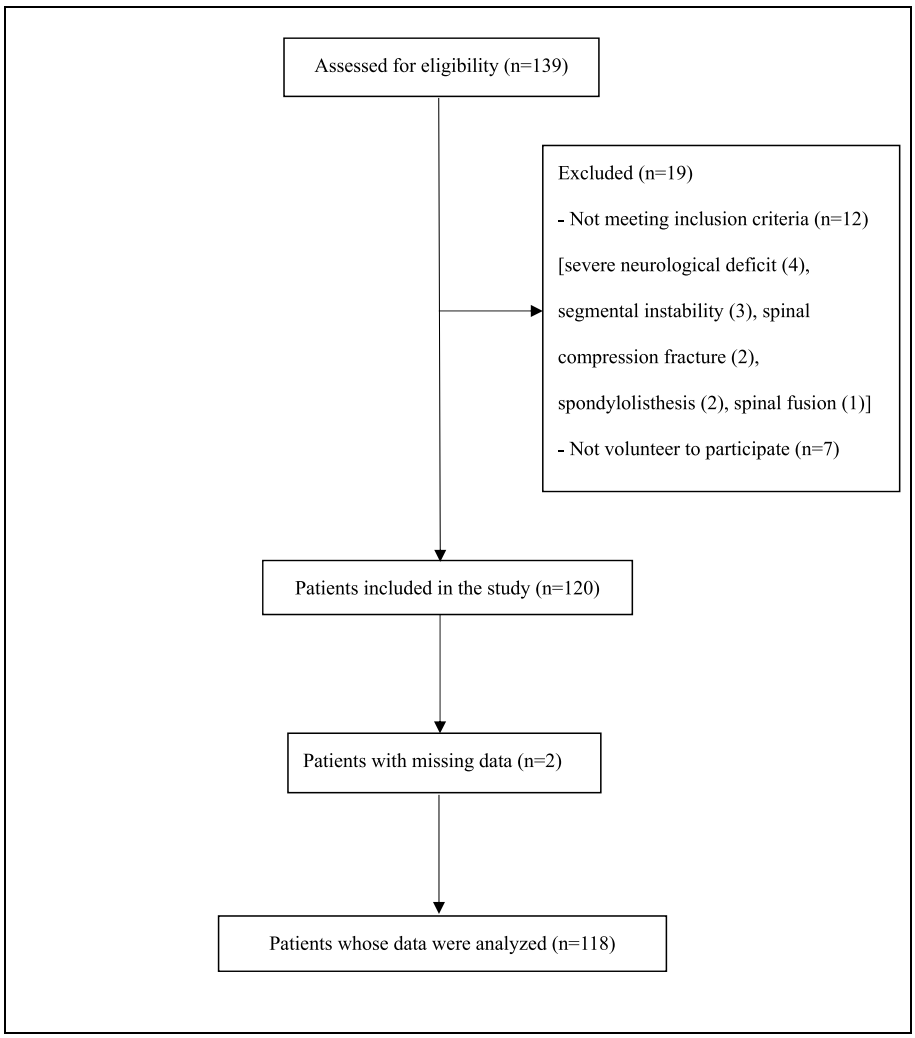

Fig. 2. Flowchart of participants.

participants can be interpreted as a percentage in line with the scores obtained from the index (Mehra et al., 2008).

2.5. Pain

The pain intensity was assessed with the Visual Analogue Scale (VAS) that is most frequently used to assess the pain intensity of patients with LBP (Ferreira-Valente et al., 2011; Bijur et al., 2001). The VAS is a scale numbered horizontally from 0 to 10 ("0" no pain, and "10" the worst pain) and 10 cm long in total. In the present study, patients were asked to mark the intensity of pain they felt during activity, at rest, and at night on this scale.

2.6. Spine structure

Spine structure was assessed with the Spinal Mouse® (Idiag, Volkerswill, Switzerland) device (Fig. 1). It is a non-invasive, radiation-free, and computer-assisted electromechanical device. The handheld wireless mouse included in the device is connected to a computer via bluetooth. The raw data reaches the computer via bluetooth and is evaluated by the software (Mannion et al., 2004; Post and Leferink 2004). The device has measurement options in different planes, provides the opportunity to evaluate both the posture and mobility of the spine, and gives valid, and reliable results (Zafereo et al., 2016; Guermazi et al., 2006; Fadaee et al., 2017; Topalidou et al., 2014). During the assessment, the processes spinosus of the spine from C7 to S3 were marked and the mouse was slide along the spine from top to bottom from the skin surface at a constant speed and pressure. The assessments were performed in an upright position for spinal posture, maximum forward flexion position for spine mobility, and raising her stretched-out arms to shoulder height with weights, designed according to the body weight, in each hand for postural competency. "Spine check score", "Posture", "Mobility" and "Postural competency" values obtained from the device were used for analysis in the present study.

2.7. Body composition

Body composition was assessed with the Bioelectrical Impedance Analysis System (Bodystat 1500, Bodystat Ltd., Douglas, UK). This analysis system is a method in which a low level electric current (500 μA–800 μA) with a frequency of 50 kHz is delivered to the body and then the resistance of the body against this electric current is measured. During the evaluation, the participant was asked to remove the metal objects from their bodies and lie on their back in a comfortable position. Then, after entering the age, height, weight, waist, and hip circumference information into the device, a total of four superficial adhesive electrodes were attached to different parts of the body (right wrist level dorsal surface, right hand second and third metacarpophalangeal joint level, right ankle dorsal surface and right foot first and second metatarsophalangeal joint level) and measurements were performed (Bizoń et al., 2021). As a result, waist-hip ratio, total body fat, fat percentage, and basal metabolic rate were taken into account for measurement

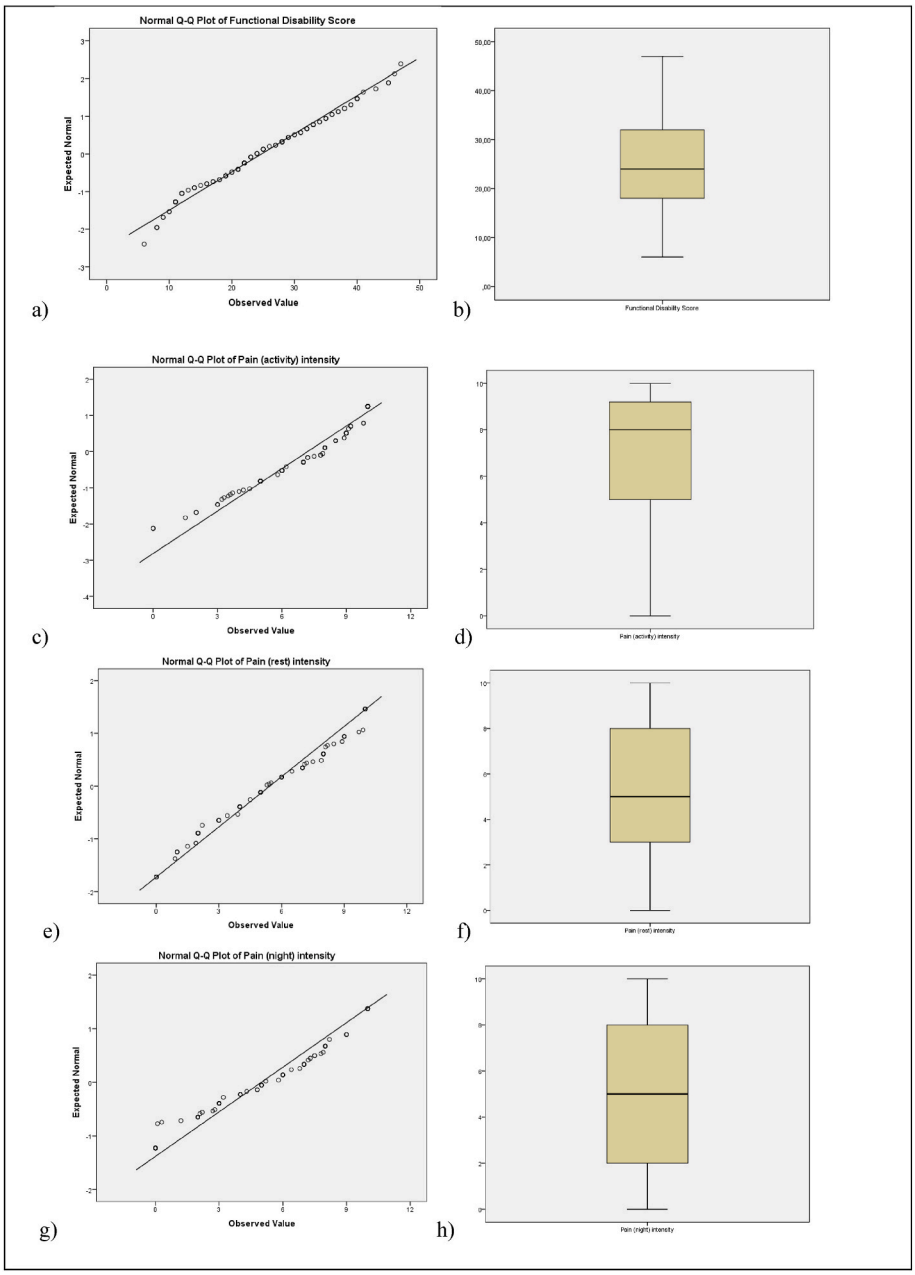

Fig. 3. The Normal Q-Q Plot (a), and the Boxplot (b) of the functional disability score, normal Q-Q Plot (c), and the Boxplot (d) of the pain (activity) intensity, normal Q-Q Plot (e), and the Boxplot (f) of the pain (rest) intensity, normal Q-Q Plot (g), and the Boxplot (h) of the pain (night) intensity.

purposes. Also, weight and height was measured on an empty stomach and without excessive fluid intake. The heights of participants while standing in bare feet were measured with a wall-fixed stadiometer (Harpenden Stadiometer, Holtain Limited, Crosswell, UK) and recorded in centimeter (cm) (Sørensen et al., 2020). The weights of participants were measured with a scale with a precission of 0.01 kg (kg). The body mass was calculated with the standard formula [body weight divided by the square of the height (kg/m^2)] (Abdellatif and Al-Hadabi 2020).

2.8. Sample size and statistical analyses

Sample size was calculated with the G*Power (G*Power Ver. 3.0.10; Franz Faul, Universitat Kiel, Germany) package program (Faul et al., 2007). According to the power analysis performed prior to the study, having the F tests, ANOVA, one-way analysis for 4 groups, with an effect size of 0.4 and a power of 90%, it was determined that at least 96 participants should be included in the study. However, a total of 120 participants were included in the study, anticipating a drop-out rate of 25%. A total of two participants' data were not included in the data analysis due to missing data. The data analysis of the study was completed with the data of 118 participants. The flowchart of participants were presented in Fig. 2.

Statistical analyses were performed using Statistical Package for the Social Sciences (version 22; IBM, Armonk, NY). The normality of all variables was determined with the Shapiro-Wilk test as well as the quantile-quantile plot (Q-Q plot) and Boxplot (for functional disability and pain intensity) (Fig. 3). Descriptive statistics of participants were given as mean and standard deviation (mean ± SD) or number (n) and percentage (%). One-way analysis of variance (ANOVA) and chi-square test were used to compare the descriptive statistics of participants according to their functional disability levels. Also, one-way ANOVA was used to compare measurement values between groups. When a

Table 1
Comparison of descriptive characteristics of patients according to their functional disability levels.

	Functional disability level				
	Mild (n = 23)	Moderate (n = 39)	Severe (n = 34)	Completely (n = 22)	p[a] value
	n (%)	n (%)	n (%)	n (%)	
Gender, n (%)					
Women	14 (60.90)	28 (71.80)	24 (70.60)	17 (77.30)	0.674
Men	9 (39.10)	11 (28.20)	10 (29.40)	5 (22.70)	
	Mean ±SD	**Mean±SD**	**Mean ±SD**	**Mean±SD**	**p[b] value**
Age, year	49.60 ± 12.20	52.58 ± 14.76	53.82 ± 12.29	49.52 ± 14.12	0.590
Height, cm	167.09 ± 10.53	162.15 ± 10.75	161.29 ± 9.29	161.76 ± 8.49	0.147
Weight, kg	85.73 ± 25.78	84.49 ± 13.38	84.28 ± 12.59	87.21 ± 21.48	0.927

SD: Standard deviation; p[a]: Chi Square Test; p[b]: One-way ANOVA.

significant difference was found between the measurement values between the groups as a result of the comparison, Bonferroni correction was used to determine which group caused this difference. The significance level (α) was set at 0.05.

3. Results

Comparison of the descriptive characteristics of patients according to their functional disability levels were presented in Table 1. There was no significant difference between the descriptive characteristics such as gender (p = .674), age (p = .590), height (p = .147), and weight (p = .927) of the patients according to their functional disability levels.

Comparison of pain intensity, spine structure, and body composition of patients according to their functional disability levels were presented in Table 2. For the pain intensity analyses, patients with mild functional disability levels had significantly lower activity (p<.001) and night pain intensity (p = 0.001) than patients with moderate, severe, and completely functional disability levels. Patients with completely functional disability levels had significantly higher rest pain intensity (p = 0.005) than patients with mild, moderate, and severe functional disability levels. Column chart for pain intensity were also presented in Fig. 4.

For the spine structure analyses, patients with mild functional disability levels had significantly better spine check scores (p = 0.001), posture (p = 0.005), and mobility (p = 0.003) than patients with moderate, severe, and completely functional disability levels. There was no significant difference between the postural competencies of the patients according to their functional disability levels (p = 0.180). Column chart for spine structure were also presented in Fig. 5.

For the body composition analyses, there was no significant difference between the waist-hip ratio (p = 0.747), body mass index (p = 0.376), and total body fat (p = 0.531) of patients according to their functional disability levels. Patients with mild functional disability levels had significantly lower fat percentage (p = 0.032), and higher basal metabolic rate (p = 0.024) than patients with moderate, severe, and completely functional disability levels. Column chart for body composition were also presented in Fig. 6.

4. Discussion

As a result of the study, it was seen that patients with mild functional disability levels had lower activity and night pain intensity, better spine check scores, posture, and mobility, and lower fat percentage and higher basal metabolic rate than patients with moderate, severe, and completely functional disability levels. Also, patients with completely functional disability levels had higher rest pain intensity than patients with mild, moderate, and severe functional disability levels.

According to Nagi's disability model, when any pathology or impairments occur, functional limitations and disabilities also occur as a result (Nagi, 1965). DLR is one of the most important causes of functional limitations or disabilities around the world (Chew et al., 2022). Also, one of the most common symptoms experienced by patients with DLR is pain (Baron et al., 2016). However, the pain intensity occurring in the vertebral column may vary depending on the pathology or the level of degenerative changes that develop due to pathology. On the other hand, it is believed that increased functional status and decreased pain would lead to a sense of well-being and improved quality of life (Amjad et al., 2022).

It was observed that studies regarding the functional disability and pain intensity of patients with DLR largely focused on the effects of any treatment method on these variables (Ahmed et al., 2022b; Kostadinović et al., 2020; Jovičić et al., 2012; Vanti et al., 2021; Danazumi et al., 2021). Considering the results obtained from these studies, it was observed that different methods such as low-level laser therapy, lumbar stabilization and thoracic mobilization exercise program, mechanical traction, and manual therapy techniques produce similar positive effects on the functional disability and pain intensity of patients with DLR.

Table 2
Comparison of pain intensity, spine structure, and body composition of patients according to their functional disability levels.

	Functional disability level				
	Mild (n=23) Mean±SD	Moderate (n=39) Mean±SD	Severe (n=34) Mean±SD	Completely (n=22) Mean±SD	p[a] value
Pain Intensity					
During activity	5.17±3.01[ǂ]	7.42±2.29	7.45±2.31	8.39±1.72	**<.001*****
At rest	3.82±3.07	5.56±2.60	5.21±3.33	7.15±3.10[ǂ]	**.005****
At night	2.59±3.44[ǂ]	4.98±3.14	5.24±3.54	6.99±3.48	**.001****
Spine structure					
Spine check scor	39.82±12.56[ǂ]	34.23±15.84	28.55±10.90	25.95±9.53	**.001****
Posture	45.00±17.11[ǂ]	35.74±21.63	29.70±16.31	26.45±17.70	**.005****
Mobility	44.13±27.23[ǂ]	28.94±15.00	25.94±12.71	30.40±20.23	**.003****
Postural competency	40.17±19.90	35.76±18.90	32.82±18.67	28.72±13.13	.180
Body composition					
Waist-hip ratio	0.86±0.05	0.87±0.06	0.89±0.08	0.88±0.08	.747
Body mass index	30.19±6.44	32.12±7.40	34.43±9.78	33.87±7.14	.376
Total body fat	29.08±15.10	33.01±15.18	36.88±11.39	38.43±17.11	.531
Fat percentage	33.35±15.25[ǂ]	38.24±14.07	42.81±12.50	45.31±13.46	**.032***
Basal metabolic rate	1708.18±314.92[ǂ]	1582.02±267.50	1442.48±357.16	1556.77±298.10	**.024***

SD: Standart deviation; p[a]: One-way ANOVA; The superscripts "ǂ" indicate the group that creates the difference according to the Bonferroni correction.
*p < .05, **p < .01.
Bold indicates significant values.

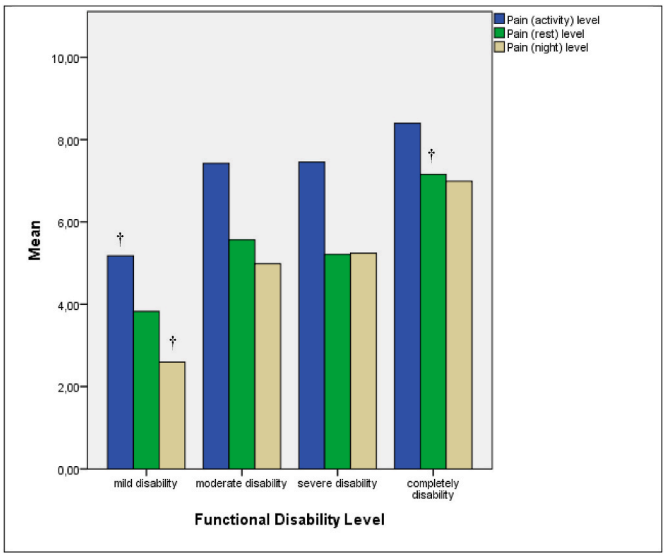

Fig. 4. Column chart for pain intensity. The superscripts "†" indicates the group that is different from other groups.

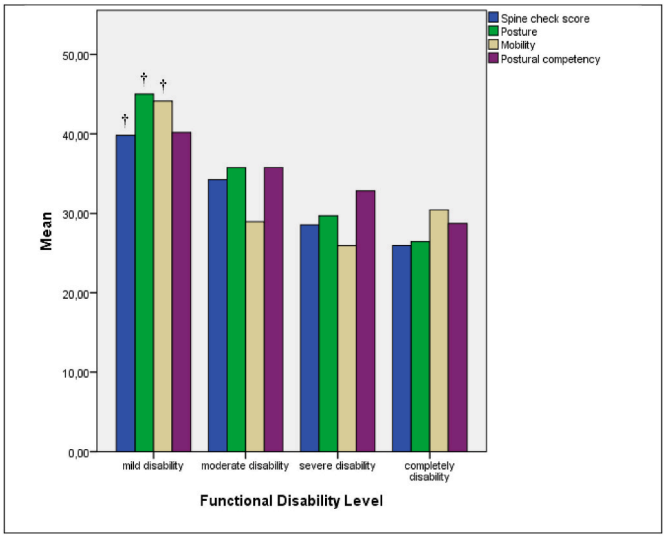

Fig. 5. Column chart for spine structure. The superscripts "†" indicates the group that is different from other groups.

Results of the present study suggested that acute DLR patients with mild functional disability levels had lower pain intensity during activity and at night than patients with moderate, severe, and completely functional disability levels, and patients with completely functional disability levels had higher activity pain intensity than patient with mild, moderate, and severe functional disability levels. This result obtained from the present study is consistent with the results of previous studies (Ahmed et al., 2022b; Kostadinović et al., 2020; Jovičić et al., 2012). These results suggest that pathological and/or degenerative changes occurring in the intervertebral discs during the DLR process cause disability and pain, the two main findings of this disease, to a similar extent.

Unlike the literature, in the present study, the spine structure and body composition of patients with DLR were compared according to their functional disability levels. Degeneration of spinal structures during the DLR process can result in irreversible chronic neural irritation (Goldstein, 2002). On the other hand, impaired body composition is a complex and multifactorial process with wide-ranging implications

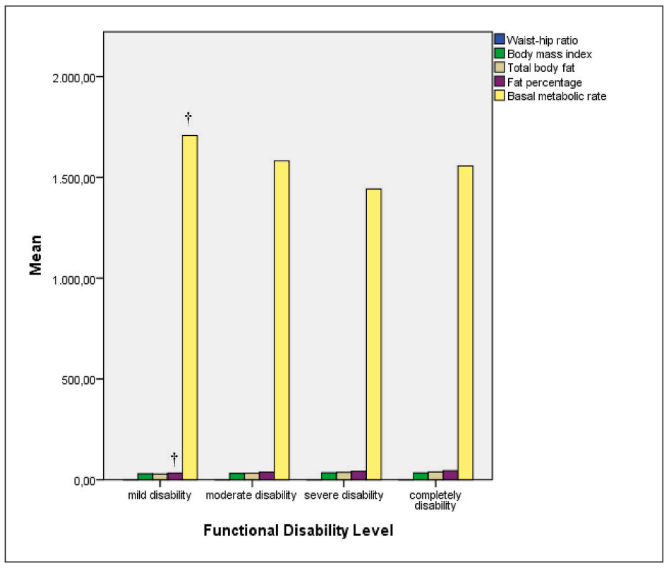

Fig. 6. Column chart for body composition. The superscripts "†" indicates the group that is different from other groups.

including increased risk for functional disability (Hruby and Hu, 2015). Also, proinflammatory cytokines produced by hypertrophic adipose tissue are partially related with LBP. Therefore, spine structure and body composition are another important issues to focus on in patients with acute DLR. Results of the present study revealed that acute DLR patients with mild functional disability had better spine check scores, posture, and mobility than the patients with moderate, severe, and completely functional disability. However, limited information about this issue in the current literature limits the discussion of the results obtained from the present study. In fact, from an anatomical and physiological perspective, this result was an expected result. Because negative changes in the spine structure and negative changes in the level of functional disability may affect each other. The question to be asked here is, do negative changes (degenerative changes, postural deficiency, irreversible chronic neural irritation) in the spine structure negatively affect functional disability, or does the functional disability cause negative changes (degenerative changes, postural deficiency, irreversible chronic neural irritation) in the spine structure through a possible decreased physical activity? We think that more studies should be conducted on these patients to clarify this situation.

Another result we obtained from the present study was DLR patients with lower functional disability levels had lower fat percentage and higher basal metabolic rate. In particular, our result that the patients with acute DLR according to low functional disability levels have a low body fat percentage supports the result found by Kim et al. (2023). Kim et al. (2023), in a study examining the effects of body composition characteristics on functional disability in patients with degenerative lumbar spinal stenosis, they reported that increased body fat percentage predicted potential severe functional disability in activities of daily living in lumbar spinal stenosis patients. In addition, the higher basal metabolic rate of patients with lower functional disability levels can be explained by the fact that their physical activity level is higher than that of patients with higher functional disability levels (Spungen et al., 2003; Innocencio da Silva Gomes et al., 2014). In fact, in the present study, body mass index, waist hip ratio, and total body fat were also examined under the title of body composition, and patients with lower functional disability levels had lower waist-hip ratio, body mass index, and total body fat. However, these results were not statistically significant. Although pain and functional disability are largely focused in patients with acute DLR, the results of this study showed that there may also be changes in spine structure and body composition in these patients. It is thought that this detail is clinically important, should be taken into

consideration by clinicians, and may provide a different perspective on the rehabilitation process of these patients.

This study had some limitations. Firstly, the study had no control group. The fact that the study included a control group was important in terms of comparing the results obtained. Secondly, this study was a cross-sectional study. In other words, dependent and independent variables were examined simultaneously. Therefore, the results obtained from the present study need to be tested with prospective studies. Thirdly, only patients with acute DLR who consulted to a one healthcare facility were included in this study. Therefore, the results obtained cannot be generalized to all patients with DLR. Fourthly, the numbers of women and men included in this study are not similar. The reflection of the disease process on the functional disability level and other variables may differ between men and women. Lastly, possible differences in disease age and patients' psychological status stand out as potential confounding factors in this study. It is recommended that future studies consider these details.

5. Conclusion

As a result of the present study it was seen that patients with mild functional disability had lower activity and night pain intensity, better spine check scores, posture, and mobility, and lower fat percentage and higher basal metabolic rate than patients with moderate, severe, and completely functional disability. Also, it was concluded that patients with completely functional disability had higher rest pain intensity than patients with mild, moderate, and severe functional disability. Although it is known that the functional disability level of patients is related to the prognosis of the disease, performing different treatment methods aimed at decreasing the functional disability level of patients by health professionals may be important in terms of coping with the disease.

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CRediT authorship contribution statement

Derya Ozer Kaya: Writing – review & editing, Visualization, Supervision, Methodology, Formal analysis, Conceptualization. **Seyda Toprak Celenay:** Writing – review & editing, Visualization, Supervision, Methodology, Conceptualization. **Erhan Secer:** Writing – original draft, Methodology, Formal analysis, Data curation. **Huseyin Bicer-oglu:** Writing – original draft, Methodology, Conceptualization.

Declaration of competing interest

The authors have no potential conflict of interests to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.msksp.2024.103133.

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