Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

regarding specific biomechanical properties.
Material and methods: Ten fresh-frozen human skull bones were precisely cut to an identical geometry by an Erbium: YAG-Laser (CARLO®, ColdAblationRobot-guidedLaserOsteotomes, AOT, Basel, Switzerland). Cranial PSIs with an identical geometry as the standard calotte were fabricated in medical and implantable-grade materials (PMMA, milled & 3D printed PEEK). PSIs (n=30) were digitized using an optical scanner for assessment of geometric accuracy. In addition, the biomechanical properties of PSIs and bone samples were assessed in a quasi-static mechanical test setup.
Results: We report preliminary data of mechanical testing (Table 1).

Table 1

Material	Force (N)	Displacement (mm)	
Bone (n=10)	1227.8 - 3527.9	6 - 13	variable bone thickness
PMMA (n=10)	1485.6	4.6	
Milled PEEK (n=10)	2427.5	24	No fracture, Test stopped
3D-printed PEEK (n=10)	1302.5	8	

Preliminary data of the accuracy assessment showed a root mean square error (RMSE) of 0.78 mm for PMMA, 0.40mm for milled PEEK and 0.49 mm for 3D printed PEEK.
Conclusion: Our preliminary data showed a difference in fracture force and displacement depending on the manufacturing technology (3D printed vs. milled) which should be considered in future models. Accuracy assessment showed RMSE under 1mm for all materials which is clinically acceptable.

BRAIN AND SPINE 2 (2022) 101190 101378
MEDICAL STUDENT TRAINING USING AUGMENTED REALITY AND CADAVER-FREE BRAIN MODELS BY UPSURGEON: AN EDUCATIONAL EFFECTIVENESS STUDY

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Background: Advances in augmented reality and 3D printing have opened the way for realistic surgical simulators. We assessed the educational effectiveness of the UpSurgeOn simulation-based training model for medical student hands-on teaching.
Methods: We organized a two-day simulation course tailored to students. On day one, three senior neurosurgeons lectured on principles of neurosurgery using virtual models and the augmented reality software of the UpSurgeOn app. They then demonstrated microsurgical approaches using life-like simulators (BrainBox, UpSurgeOn). The surgical field was projected to large high-definition screens by a robotic-assisted exoscope (RoboticScope, BHS Technologies). On day two, the students were equipped with microsurgical instruments and simulated a pterional, temporal and endoscopic retrosigmoid approach. They were further instructed in the handling of the RoboticScope to practice five clipping procedures using the Aneurysm BrainBox under supervision by the faculty. All students filled out a 15-item questionnaire to evaluate their learning experience.
Results: Sixteen medical students participated in the course, seven of which had never been exposed to neuroanatomical dissections before. No student had previous experience with UpSurgeOn. All participants agreed the app helped develop anatomical orientation and familiarity with neurosurgical skills. They unanimously agreed this model should be part of residency training. Fourteen out of sixteen students rated their overall learning experience as totally positive, the remaining two as rather positive. Over 80% agreed that both the brain surface and the vascular and skull base anatomy were realistic. Yet, three students believed that the simulation did not help them become familiar with the real tactile sensation of the brain.
Conclusion: The UpSurgeOn educational app and real life-like cadaver-free models enable a highly effective and immersive approach to surgical training of medical students in the form of hands-on simulations. Comparative trials may identify a long-term benefit of UpSurgeOn-assisted simulation-based training over conventional training in the future.

BRAIN AND SPINE 2 (2022) 101190 101379
HIGH-RESOLUTION 7 TESLA MAGNETIC RESONANCE METABOLIC IMAGING IN EPILEPSY PATIENTS

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Background: Our institution developed a new method for fast and high-resolution metabolic imaging using magnetic resonance spectroscopic imaging (MRSI) for 7T MRI systems. After validation in healthy subjects (Hingerl et al. Invest Radiol. 2020 Apr;55(4):239-248) and glioma patients (Hangel et al. NeuroImage: Clinical, Volume 28, 2020, 102433) we now applied this method for the investigation of refractive and MR-negative epilepsy. We can now give an update to our preliminary data with initially 10 patients.
Methods: 23 patients (27±8 years, 14 female) with refractive epilepsy (14 MR-negative) were scanned and evaluated in this preliminary study phase. The 7T MRI protocol included morphological imaging (T1w, T2w, FLAIR, white-matter suppressed T2w, SWI) and 3D MRSI that covered the brain with 3.4 mm resolution in 15 min scan time. After postprocessing and spectral quantification, the resulting maps of the ratios of cholin (Cho), creatine (Cr), glutamate (Glu), glutamine (Gln), myo-inostitol (Ins) and glutathione (GSH) to N-acetylaspartate (NAA) were compared to the available clinical neurological assessments based on MRI and EEG and potential post-resective histology. Correspondence was classified as good, partial or no correspondence based on the overall MRSI-results on the lobe level.
Results: 21 scans were of utilisable quality. We found good correspondence between clinical information and MRSI in thirteen cases, partial correspondence in five, and no correspondence in three. Metabolic hotspots could be discerned for Cho/NAA in 17/21, for Cr/NAA in 13/21, for Glu/NAA in 6/21, for Ins/NAA in 11/21, and for GSH in 7/21.
Conclusion: We found that in our initial data, MRSI appears to be able to deliver spatial information on difficult-to-locate epilepsy cases. At least Cho/NAA, known from previous research using methods with lesser spatial selectivity, can define hotspots with higher resolution than ever before. We will need more data to establish metabolic profiles for specific etiologies.

BRAIN AND SPINE 2 (2022) 101190 101380
TELEMEDICAL FOLLOW-UP IN PATIENTS AFTER DECOMPRESSIVE SPINE SURGERY – A RETROSPECTIVE, SINGLE CENTER ANALYSIS

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Introduction: During the COVID-19 pandemic telemedicine became an indispensable tool in health care. In our institution, patients received a telemedical follow-up after decompressive spine surgery to reduce the patient load in the outpatient clinic and consequently to minimize the risk of infection. The aim of our study was to assess the efficacy of telemedical follow- up and to thus conclude whether the routine impolementation of telemedicine would be a reasonable measure.
Methods: Patients after posterior cervical decompression, lumbar decompression or sequestrectomy were identified retrospectively from our database. 479 patients received a telemedical follow-up and were included into this analysis. The patients were called 6 weeks (+/- 1 week) after surgery and a standardized questionnaire was applied. Additionally, physical visits at our outpatient clinic were recommended due to uncertainty and/or persistent pain or discomfort. Demographic data, bivariate analysis and Cox regression were performed for statistical analysis.
Results: Despite the telemedical follow-up 139 (29%) of the 479 patients insisted on a physical visit. Persistent or recurrent radiculopathy (HR 2.46, $p<0.001$), back- or neck pain (HR 1.69, $p=0.011$), Wound-healing disorders (HR 2.27, $p=0.005$) and subjective impairment of quality of life (HR 2.70, $p<0.001$)

were were mainly causes for a physical visit after a telemedical follow-up. However, sex (p=0.503), age (p=0.755) or decompressions of more than 2 levels (p=0,596) showed no significant correlation on representation. Revision surgery was performed in 43 (9%) patients.
Conclusion: Telemedical follow-up showed a benefit in reducing the outpatient visits after decompressive spine surgery. 70% of the patients included in this retrospective analysis did not require a postoperative physical evaluation. Nevertheless, the system screens out patients requiring further treatment. According to our results the postoperative outpatient visit after cervical and lumbar decompressive surgery may be substituted in order to relieve the outpatient clinic even in a post-COVID era.

BRAIN AND SPINE 2 (2022) 101190 101381
SPONTANEOUS BRAIN ABSCESS FORMATION: CHALLENGE OF A CHANGING PATHOGEN SPECTRUM OVER THE LAST 21 YEARS

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Brain abscess is a life-threatening condition. The incidence ranges between 0.3 to 1.3 cases per 100.000. Despite advanced surgical strategies and recent antibiotic treatment mortality rate remains of up to 20%. Intracranial abscess formation is mostly associated with prior sinusitis, mastoiditis or dental infection. Recent literature suggests an increase of odontogenic pathogens.
We analyzed the hospital patient data base for all patients who had undergone surgery of an intracranial abscess from 2000 to mid 2021 at our institution. Outcome was noted by modified Rankin score (mRS) at the time of discharge and at first follow-up 3-6 months after discharge. The primary endpoint was defined as surgical treatment. The secondary endpoint was defined as outcome.
During a 21-year period, 218 patients were treated. We identified 73 cases of spontaneous intracranial abscess formation without prior brain surgery.All patients received open abscess evacuation.Follow-up after 3-6 months was available in 56 patients of which42 patients had a good outcome (mRS 0-3) while six patients had a bad outcome and nine patients had died in hospital (mRS 4-6). The number of treated cases were clustered in five-year periods. The incidence increased every five years from 2000 to 2021. The major cause of infection were streptococci of the anginosus group (SAG) and gram-negative anaerobes. During the ongoing period the second largest group were rarer pathogens such as gram-positive rods, fungi and parasites. The relation of SAG and rarer pathogens has shifted towards the latter.
The number of cases of intracranial brain abscess formation has increased while the spectrum of pathogens has changed over the last two decades. We want to encourage neurosurgeons and other physicians to think out of the box when making the diagnosis of brain abscess by highlighting the increased number in cases with rare pathogens without a clear path of primary dissemination.

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NON-INVASIVE LOW PULSED ELECTRICAL FIELDS FOR INDUCING TRANSIENT BBB DISRUPTION DEPICTED BY TRAMS

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Background: Poor penetration of therapeutics across the blood-brain barrier (BBB) is a major challenge in treating brain diseases. We have developed a method to induce transient/safe BBB disruption (BBBd) by applying a short non-invasive treatment of low pulsed electric fields (L-PEFs).
Methods: L-PEFs (6-100 sec, 0.005% on) were applied to mice brains using two plate electrodes pressed against the skull. BBBd was depicted and quantified using MRI-based treatment response assessment maps (TRAMs): multiple delayed-contrast T1-MRIs were co-registered to the first scan and pixel-by-pixel fits to a bi-exponential function were used to determine volume/intensity of BBBd regions. The TRAMs correlation with a numerical simulation of the electric fields distribution was studied. Doxorubicin (580Da), Albumin-Evansblue dye (70KDa) and IgG (150KDa) were used to study drug penetration into the brain.
Results: BBBd induced by L-PEFs was depicted in the TRAMs but not in conventional T1-Gd. BBBd intensity/volume increased linearly with the voltage and number of pulses. Based on the simulations, the electric fields in the disrupted volume were only 28-65 V/cm. TRAMs showed full BBB recovery after 1-4 hours depending on treatment parameters. No signs of damage were observed in the treated brains and the mice showed no neurological deficits post L-PEFs. The TRAMs results were consistent with the Evens-Blue results, showing areas BBBd mainly in the cortex of treated animals. IgG showed extravasation in treated brains but not in sham. Doxorubicin concentration in treated brains 4 hours post L-PEFs was 885±85 μM which is X230 its IC50 in GL261 glioma cells.
Conclusion: These results demonstrate the feasibility of applying short L-PEFs treatments for non-invasive/transient BBBd, enabling efficient delivery of small/large molecules into mice brains. Our simulation results demonstrate the feasibility of extending to human brain size, thus leading the way to new means for non-invasive drug delivery into the CNS.

BRAIN AND SPINE 2 (2022) 101190 101383
GLOBAL TRAINING PROJECT 2021: REPORT OF AN INTERNATIONAL NON-PROFIT INITIATIVE TO BRING CADAVER-FREE TRAINING TO LMICS

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Standardisation of surgical education and training is emerging as a key aspect in guaranteeing equal access to optimal surgical care worldwide. Central to neurosurgical care, specialised education is particularly needed in low-middle-income countries (LMICs), where opportunities for neurosurgical training are limited due to social and economic constraints. Ultimately, this under-resourced critical need underscoresthe crucial importance of developing access to effective, low-cost and cadaver-free neurosurgical training worldwide.
From April to November 2021, the authors organised a non-profit initiative consisting of a series of cadaver-free courses based on a novel integration of virtual and hands-on simulations in 11 LMICs. This project emerged from a collaboration between the Young Neurosurgeons Forum of the World Federation of Neurological Societies (WFNS), UpSurgeOn, an Italian hi-tech company specialising in simulation technologies, and the Neurotrauma Research Group of Cambridge (NIHR).
This project aimed at demonstrating how a cadaver-free hybrid (virtual/hands-on) training system could potentially accelerate the learning curve for neurosurgical residents, particularly in settings with limited training possibilities. The 168 participants in the project completed an online survey after each course.
The results showed overall that the majority of participants agreed that simulated training proved to be an effective method of training. This training method integrates theoretical with practical knowledgeon real patient/cadavers.
The purpose of this study sought to demonstrate how highly realistic hybrid/virtual simulators could replicate the operating room experience and lessen the need for cadaveric dissection as being less central in LMIC's. In turn, this mode of simulation training is likely to result in being beneficial to patients and in improving the overall quality and a safety of neurosurgical care globally. Yet, as neurosurgical simulation, still in an embryonic stage, requires further investigation on a broader and more in-depth scale.

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TREATMENT PLANNING FOR PATIENTS UNDERGOING NEUROVASCULAR SURGERIES USING PATIENT SPECIFIC 3D PRINTED MODELS AND MIXED REALITY: METHODOLOGICAL APPROACH

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