

## Navigation systems in maxillofacial surgery and neurosurgery and their potential advantages

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**Operating microscopes, navigation systems and intraoperative neurophysiological monitoring are essential in modern neurosurgical and maxillofacial procedures. Advances in surgical planning in neurosurgery and maxillofacial surgery led to the more common navigation system that helps surgeons know more information and ultimately do more for their patients. The benefits of a contemporary navigation system in the complicated brain, skull-base, maxillofacial and spine surgery are undeniable. Workflow analyses and cost-benefit evaluations must be carried out to increase the efficiency of neuro-navigation systems in the next future.**

Operating microscopes, navigation systems and intraoperative neurophysiological monitoring are essential in modern neurosurgical and maxillofacial

procedures (1-8). Advances in surgical planning in neurosurgery and maxillofacial surgery led to the more common use of navigation systems that helps surgeons

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to know more information and ultimately do more for their patients (9-16). All intraoperative navigation systems incorporate a computer digitizer to track the location of the patient and instruments in space. Four different digitizer modalities have been developed: optical, electromagnetic, electromechanical, and ultrasonographic. Optical tracking is most used (17). Registration is accomplished by identifying specific fiducial markers on the virtual patient, as seen on the navigation system monitor (17).

Innovation in the medical equipment industry led to the update of navigation equipment such that the systems are now more user friendly, have dynamic referencing and offer multiple tracking capabilities, including 3D imaging (18). In addition, the systems can also be integrated with external devices like microscopes, endoscopes and ultrasound (18-27).

The benefits of the contemporary navigation system in the complicated brain, skull-base and spine surgery are undeniable (28-37). For example, small lesions in eloquent brain areas can be operated on more radically with less morbidity than the pre-neuro-navigation era (18, 24, 38-40). Similarly, in the case of external drainage and small ventricles, navigation can be helpful (41-43).

Craniofacial approaches with intra-operative neuro-navigational guidance in a multidisciplinary setting allow safe resection of large tumors of the upper clivus and the paranasal sinuses involving the anterior skull base (18, 44-46). Complex skull base surgery with the involvement of bony structures appears to be an ideal field for advanced navigation techniques, given the lack of intraoperative shift of relevant structures (47-50). Also, in oral surgeries, the usefulness of the navigation system has been indicated by its surgical applications in craniomaxillofacial trauma, orthognathic surgeries, head and neck pathological resections, complex skull base surgeries and surgery involving temporomandibular joints (9, 51-63).

In maxillofacial surgeries, open reduction and internal fixation for the treatment of facial fractures remains the standard of care for most facial fractures. However, symmetric repair of complex facial fractures remains extremely challenging (17, 64-71). The use of a navigation system permits to treat

of complex facial fractures, reducing the risk of a discrepancy between symmetrically opposite facial bones. It has the benefits of combining 3D computed tomography (CT) and computer-aided design technology for the development of custom-designed prostheses are applied in the repair of posttraumatic and congenital facial contour deficiencies (64, 72-86).

Although primarily developed for a neurosurgical application, intraoperative navigation has gained acceptance even in maxillofacial surgery with an increasing field of indications (87). Heiland et al. (87) showed one of the best examples of the benefit of navigation in secondary orbital reconstruction in maxillofacial surgery.

Computer-assisted surgery has evolved from its earliest introduction with utility in the neurosurgical field. Within the past twenty years, optical navigation systems have emerged and developed into a great tool for dentistry and craniomaxillofacial surgery (88). Currently, computer-assisted surgery is useful for orthognathic and temporomandibular joint surgery, facial trauma, maxillomandibular reconstruction, implantology, and restorative dentistry (88). Similarly, ablative tumor surgery and orbital and midface reconstruction, as much as orthognathic surgery, require detailed planning using CT or magnetic resonance imaging (MRI) (89). These techniques also allow the simulation of complex surgeries preoperatively. Proper reconstruction depends on reliable information to choose the correct type of grafts and to predict the outcome.

Hohlweg-Majert et al. (89) reported in their study the benefit and indications of computer-assisted surgery in the treatment of 107 patients who underwent craniomaxillofacial surgery, showing that intraoperative navigation makes tumor and reconstructive surgery more reliable by showing the safety margins, saving vital structures, and leading the reconstruction to preoperatively planned objectives.

In spine surgery, the navigation system significantly reduces intraoperative radiation time, puncture time, and operation time, reshapes the learning curve, and improves percutaneous surgical treatment of spine fractures (90-99). Workflow

analyses and cost-benefit evaluations must be carried out to increase the efficiency of neuro-navigation systems in the next future (18).

Advances and innovations in neuroimaging, surgical techniques and medical equipment over the last decades have given an enormous boost to the improvement and success of contemporary neurosurgery and maxillofacial surgery. One of these advances has been image-guided surgery which can be defined as any method that uses imaging technology to enhance brain, maxillofacial and spine surgery (100). However, more and more assessments of neuro-navigation from the perspective of health care system efficiency, effectiveness, and economy are required (18).

With the opportunity to perform preoperative planning, surgical simulation and postoperative prediction, computer-assisted navigation shows great value in improving the accuracy of maxillofacial surgery and neurosurgery, reducing operational risk and postsurgical morbidity, and restoring facial symmetry (101-138).

## REFERENCES

- Tomita Y, Kurozumi K, Fujii K, Shimazu Y, Date I. Neurosurgery for brain metastasis from breast cancer. *Transl Cancer Res.* 2020; 9 (8):5063-5076.
- Inchingolo F, Santacroce L, Ballini A, et al. Oral Cancer: A Historical Review. *Int J Environ Res Public Health.* 2020; 17(9):3168.
- Condino S, Montemurro N, Cattari N, D'Amato R, Thomale U, Ferrari V, Cutolo F. Evaluation of a Wearable AR Platform for Guiding Complex Craniotomies in Neurosurgery. *Ann Biomed Eng.* 2021; 49 (9):2590-2605.
- Montemurro N, Condino S, Cattari N, D'Amato R, Ferrari V, Cutolo F. Augmented Reality-Assisted Craniotomy for Parasagittal and Convexity En Plaque Meningiomas and Custom-Made Cranio-Plasty: A Preliminary Laboratory Report. *Int J Environ Res Public Health.* 2021; 18 (19):9955.
- Montemurro N, Scerrati A, Ricciardi L, Trevisi G. The Exoscope in Neurosurgery: An Overview of the Current Literature of Intraoperative Use in Brain and Spine Surgery. *J Clin Med.* 2021; 11 (1):223.
- Montemurro N, Anania Y, Cagnazzo F, Perrini P. Survival outcomes in patients with recurrent glioblastoma treated with Laser Interstitial Thermal Therapy (LITT): A systematic review. *Clin Neurol Neurosurg.* 2020; 195:105942.
- Di Venere D, Pettini F, Nardi GM, et al. Correlation between parodontal indexes and orthodontic retainers: prospective study in a group of 16 patients. *Oral Implantology* 2017; 10:78-86.
- Lizana J, Montemurro N, Aliaga N, Marani W, Tanikawa R. From textbook to patient: a practical guide to train the end-to-side microvascular anastomosis. *Br J Neurosurg.* 2021; 7:1-5.
- Anand M, Panwar S. Role of Navigation in Oral and Maxillofacial Surgery: A Surgeon's Perspectives. *Clin Cosmet Investig Dent.* 2021; 13:127-139.
- Rapone B, Corsalini M, Converti I, et al. Does Periodontal Inflammation Affect Type 1 Diabetes in Childhood and Adolescence? A Meta-Analysis. *Front. Endocrinol.* 2020; 11:278.
- Rapone B, Ferrara E, Corsalini M, et al. The Effect of Gaseous Ozone Therapy in Conjunction with Periodontal Treatment on Glycated Hemoglobin Level in Subjects with Type 2 Diabetes Mellitus: An Unmasked Randomized Controlled Trial. *Int. J. Environ. Res. Public Health* 2020; 17 (15):54675.
- Quaglia E, Moscufo L, Corsalini M, et al. Polyamide vs silk sutures in the healing of postextraction sockets: a split mouth study. *Oral Implantology* 2018; 11(2):115-120.
- Rapone B, Ferrara E, Santacroce L, et al. Gingival Crevicular Blood as a Potential Screening Tool: A Cross Sectional Comparative Study. *Int J Environ Res Public Health.* 2020; 17 (20):7356.
- Inchingolo F, Martelli FS, Gargiulo Isacco C, et al. Chronic Periodontitis and Immunity, Towards the Implementation of a Personalized Medicine: A Translational Research on Gene Single Nucleotide Polymorphisms (SNPs) Linked to Chronic Oral Dysbiosis in 96 Caucasian Patients. *Biomedicines.* 2020; 8(5):115.
- Montemurro N. Glioblastoma Multiforme and Genetic Mutations: The Issue Is Not Over Yet. An Overview of the Current Literature. *J Neurol Surg A Cent Eur Neurosurg.* 2020; 81 (1):64-70.
- Perrini P, Pieri F, Montemurro N, Tiezzi G, Parenti

- GF. Thoracic extradural haematoma after epidural anaesthesia. *Neurol Sci.* 2010; 31 (1):87-88.
17. Strong EB, Rafii A, Holhweg-Majert B, Fuller SC, Metzger MC. Comparison of 3 optical navigation systems for computer-aided maxillofacial surgery. *Arch Otolaryngol Head Neck Surg.* 2008; 134 (10):1080-4.
  18. Spetzger U, Stiehl HS, Rohr K, Gilsbach M. Navigated brain surgery: an interdisciplinary introduction. In: Spetzger U, Stiehl HS, Gilsbach M (eds). *Navigated brain surgery.* Mainz: Verlag; 1999: 5-9.
  19. Perrini P, Montemurro N, Caniglia M, Lazzarotti G, Benedetto N. Wrapping of intracranial aneurysms: Single-center series and systematic review of the literature. *Br J Neurosurg.* 2015; 29:785-791.
  20. Perrini P, Montemurro N, Iannelli A. The contribution of Carlo Giacomini (1840-1898): the limbus Giacomini and beyond. *Neurosurgery.* 2013; 72 (3):475-481.
  21. Montemurro N, Benet A, Lawton MT. Julius Caesar's Epilepsy: Was It Caused by A Brain Arteriovenous Malformation? *World Neurosurg.* 2015; 84 (6):1985-1987.
  22. Montemurro N, Herbet G, Duffau H. Right Cortical and Axonal Structures Eliciting Ocular Deviation During Electrical Stimulation Mapping in Awake Patients. *Brain Topogr.* 2016; 29 (4):561-571.
  23. Rapone B, Converti I, Santacroce L, et al. Impact of Periodontal Inflammation on Nutrition and Inflammation Markers in Hemodialysis Patients. *Antibiotics (Basel).* 2019; 8 (4):209.
  24. Inchingolo F, Tatullo M, Pacifici A, et al. Use of dermal-fat grafts in the post-oncological reconstructive surgery of atrophies in the zygomatic region: clinical evaluations in the patients undergone to previous radiation therapy. *Head Face Med.* 2012; 8:33.
  25. Inchingolo F, Tatullo M, Abenavoli FM, et al. Severe anisocoria after oral surgery under general anesthesia. *Int J Med Sci.* 2010; 7 (5):314-8.
  26. Benet A, Montemurro N, Lawton MT. Management of a Ruptured Posterior Inferior Cerebellar Artery (PICA) Aneurysm With PICA-PICA In Situ Bypass and Trapping: 3-Dimensional Operative Video. *Oper Neurosurg (Hagerstown).* 2017; 13 (3):400.
  27. Marani W, Mannarà F, Noda K, et al. Management of an Uncommon Complication: Anterior Choroidal Artery Occlusion by Posterior Clinoid Process Detected Through Intraoperative Monitoring After Clipping of Paraclinoid Aneurysm: 2-Dimensional Operative Video. *Oper Neurosurg (Hagerstown).* 2021; 21 (2):E124-E125.
  28. Rapone B, Ferrara E, Santacroce L, Topi S, Gnoni A, Dipalma G, Mancini A, Di Domenico M, Tartaglia GM, Scarano A, Inchingolo F. The Gaseous Ozone Therapy as a Promising Antiseptic Adjuvant of Periodontal Treatment: A Randomized Controlled Clinical Trial. *International Journal of Environmental Research and Public Health* 2022; 19(2):985.
  29. Corsalini M, Di Venere D, Carossa M, et al. Comparative clinical study between zirconium-ceramic and metal-ceramic fixed rehabilitations. *Oral Implantology* 2018; 11:150-160.
  30. Grassi FR, Grassi R, Rapone B, Gianfranco A, Balena A, Kalemaj Z. Dimensional changes of buccal bone plate in immediate implants inserted through open flap, open flap and bone grafting, and flapless technique. A CBCT randomized controlled clinical trial. *Clin Oral Implants Res.* 2019; 30:1155-1164.
  31. Montemurro N, Perrini P, Marani W, Chaurasia B, Corsalini M, Scarano A, Rapone B. Multiple Brain Abscesses of Odontogenic Origin. May Oral Microbiota Affect Their Development? A Review of the Current Literature. *Applied Sciences.* 2021; 11 (8):3316.
  32. Murrone D, Romanelli B, Montemurro N, Chirchiglia D, Ierardi A. Falcine meningioma in Von Hippel-Lindau disease: An unusual association. *Surg Neurol Int.* 2018; 9:37.
  33. Owen CM, Montemurro N, Lawton MT. Microsurgical Management of Residual and Recurrent Aneurysms After Coiling and Clipping: An Experience With 97 Patients. *Neurosurgery.* 2015; Suppl 1:92-102.
  34. Montemurro N, Perrini P, Rapone B. Clinical Risk and Overall Survival in Patients with Diabetes Mellitus, Hyperglycemia and Glioblastoma Multiforme. A Review of the Current Literature. *Int J Environ Res Public Health.* 2020; 17(22):8501.
  35. Pasqualetti F, Montemurro N, Desideri I, et al. Impact of recurrence pattern in patients undergoing a second surgery for recurrent glioblastoma. *Acta Neurol Belg.* 2021; Aug 16.
  36. Montemurro N, Perrini P, Vannozzi R. Epidural spinal

- cord compression in Langerhans cell histiocytosis: a case report. *Br J Neurosurg.* 2013; 27 (6):838-839.
37. Montemurro N. Intracranial hemorrhage and COVID-19, but please do not forget “old diseases” and elective surgery. *Brain Behav Immun.* 2021; 92:207-208.
  38. Fanelli GN, Grassini D, Ortenzi V, et al. Decipher the Glioblastoma Microenvironment: The First Milestone for New Groundbreaking Therapeutic Strategies. *Genes (Basel).* 2021; 12 (3):445.
  39. Montemurro N, Perrini P, Blanco MO, Vannozzi R. Second surgery for recurrent glioblastoma: A concise overview of the current literature. *Clin Neurol Neurosurg.* 2016; 142:60-64.
  40. Montemurro N, Fanelli GN, Scatena C, et al. Surgical outcome and molecular pattern characterization of recurrent glioblastoma multiforme: A single-center retrospective series. *Clin Neurol Neurosurg.* 2021; 207:106735.
  41. Montemurro N, Indaimo A, Di Carlo DT, Benedetto N, Perrini P. Surgical Treatment of Long-Standing Overt Ventriculomegaly in Adults (LOVA): A Comparative Case Series between Ventriculoperitoneal Shunt (VPS) and Endoscopic Third Ventriculostomy (ETV). *Int J Environ Res Public Health.* 2022; 19 (4):1926.
  42. Mishra R, Narayanan MDK, Umana GE, Montemurro N, Chaurasia B, Deora H. Virtual Reality in Neurosurgery: Beyond Neurosurgical Planning. *Int J Environ Res Public Health.* 2022; 19 (3):1719.
  43. Das S, Montemurro N, Ashfaq M, Ghosh D, Sarker AC, Khan AH, Dey S, Chaurasia B. Resolution of papilledema following ventriculoperitoneal shunt or endoscopic third ventriculostomy for obstructive hydrocephalus: A pilot Study. *Medicina.* 2022; 58 (2):281.
  44. Chauhan H, Rao SG, Chandramurli BA, Sampath S. Neuro-navigation: An Adjunct in Craniofacial Surgeries: Our Experience. *J Maxillofac Oral Surg.* 2011; 10 (4):296-300.
  45. Wirtz CR, Albert FK, Schwaderer M, Heuer C, Staubert A, Tronnier VM, Knauth M, Kunze S. The benefit of neuronavigation for neurosurgery analyzed by its impact on glioblastoma surgery. *Neurol Res.* 2000; 22 (4):354-60.
  46. Inchingolo F, Tatullo M, Abenavoli FM, et al. Surgical treatment of depressed scar: a simple technique. *Int J Med Sci.* 2011;8(5):377-9.
  47. Lutz JC, Hostettler A, Agnus V, Nicolau S, George D, Soler L, Rémond Y. A New Software Suite in Orthognathic Surgery : Patient Specific Modeling, Simulation and Navigation. *Surg Innov.* 2019; 26 (1):5-20.
  48. Inchingolo F, Ballini A, Cagiano R, et al. Immediately loaded dental implants bioactivated with platelet-rich plasma (PRP) placed in maxillary and mandibular region. *Clin Ter.* 2015; 166 (3):e146-52.
  49. Owen CM, Montemurro N, Lawton MT. Blister Aneurysms of the Internal Carotid Artery: Microsurgical Results and Management Strategy. *Neurosurgery.* 2017; 80 (2):235-247.
  50. Di Venere D, Corsalini M, Nardi GM, Laforgia A, Grassi FR, Rapone B, Pettini F. Obstructive site localization in patients with Obstructive Sleep Apnea Syndrome: a comparison between otolaryngologic data and cephalometric values. *Oral Implantology* 2017; 10:295–310.
  51. Lizana J, Reinoso CMD, Aliaga N, Marani W, Montemurro N. Bilateral central retinal artery occlusion: An exceptional complication after frontal parasagittal meningioma resection. *Surg Neurol Int.* 2021; 12:397.
  52. Scarano A, Inchingolo F, Murmura G, Traini T, Piattelli A, Lorusso F. Three-Dimensional Architecture and Mechanical Properties of Bovine Bone Mixed with Autologous Platelet Liquid, Blood, or Physiological Water: An In Vitro Study. *Int J Mol Sci.* 2018; 19 (4):1230.
  53. Inchingolo AD, Inchingolo AM, Bordea IR, et al. SARS-CoV-2 Disease Adjuvant Therapies and Supplements Breakthrough for the Infection Prevention. *Microorganisms.* 202; 9 (3):525.
  54. Scarano, A.; Inchingolo, F.; Rapone, B.; Festa, F.; Tari, S.R.; Lorusso, F. Protective Face Masks: Effect on the Oxygenation and Heart Rate Status of Oral Surgeons during Surgery. *Int. J. Environ. Res. Public Health* 2021, 18, 2363.
  55. Rapone B, Ferrara E, Santacroce L, et al. Periodontal Microbiological Status Influences the Occurrence of Cyclosporine-A and Tacrolimus- Induced Gingival Overgrowth. *Antibiotics* 2019; 8:124.
  56. Corsalini M, Di Venere D, Sportelli P, et al. Evaluation of prosthetic quality and masticatory efficiency in

- patients with total removable prosthesis: study of 12 cases. *Oral Implantology* 2018; 11:230–240.
57. Corsalini M, Di Venere D, Rapone B, Stefanachi G, Laforgia A, Pettini F. Evidence of signs and symptoms of Craniomandibular Disorders in Fibromyalgia patients. *The Open Dent Journal* 2017; 11(1):91–98.
  58. Rapone B, Ferrara E, Montemurro N, et al. Oral Microbiome and Preterm Birth: Correlation or Coincidence? A Narrative Review. *Open Access Maced. J. Med. Sci.* 2020; 8:123–132.
  59. Kalemaj Z, Scarano A, Valbonetti L, Rapone B, Grassi FR. Bone response to four dental implants with different surface topography: a histologic and histometric study in minipigs. *Int J Periodontics Restorative Dent.* 2016; 36(5):745–54.
  60. Owen CM, Montemurro N, Lawton MT. Microsurgical Management of Residual and Recurrent Aneurysms After Coiling and Clipping: An Experience With 97 Patients. *Neurosurgery.* 2015; Suppl 1:92–102.
  61. Lorusso F, Noumbissi S, Inchingolo F, Rapone B, Khater AGA, Scarano A. Scientific Trends in Clinical Research on Zirconia Dental Implants: A Bibliometric Review. *Materials* 2020, 13:5534.
  62. Scarola R, Montemurro N, Ferrara E, Corsalini M, Converti I, Rapone B. Temporomandibular Disorders and Fibromyalgia: A Narrative Review. *Open Access Maced J Med Sci [Internet].* 2021; 9 (F):106–12.
  63. Montemurro N, Murrone D, Romanelli B, Ierardi A. Postoperative Textiloma Mimicking Intracranial Rebleeding in a Patient with Spontaneous Hemorrhage: Case Report and Review of the Literature. *Case Rep Neurol.* 2020; 12 (1):7–12.
  64. Zhang X, Ye L, Li H, Wang Y, Dilxat D, Liu W, Chen Y, Liu L. Surgical navigation improves reductions accuracy of unilateral complicated zygomaticomaxillary complex fractures: a randomized controlled trial. *Sci Rep.* 2018; 8 (1):6890.
  65. Binder WJ, Kaye A. Reconstruction of posttraumatic and congenital facial deformities with three-dimensional computer-assisted custom-designed implants. *Plast Reconstr Surg.* 1994; 94 (6):775–85.
  66. Borsani E, Bonazza V, Buffoli B, et al. Beneficial Effects of Concentrated Growth Factors and Resveratrol on Human Osteoblasts In Vitro Treated with Bisphosphonates. *Biomed Res Int.* 2018; 2018:4597321.
  67. Bellocchio L, Bordea IR, Ballini A, et al. Environmental Issues and Neurological Manifestations Associated with COVID-19 Pandemic: New Aspects of the Disease? *Int J Environ Res Public Health.* 2020; 17 (21):8049.
  68. Montemurro N, Santoro G, Marani W, Petrella G. Posttraumatic synchronous double acute epidural hematomas: Two craniotomies, single skin incision. *Surg Neurol Int.* 2020; 11:435.
  69. Rapone B, Nardi GM, Di Venere D, Pettini F, Grassi FR, Corsalini M. Oral hygiene in patients with oral cancer undergoing chemotherapy and/or radiotherapy after prosthesis rehabilitation: protocol proposal. *Oral Implantology* 2016; 9 (01 suppl): 90–97.
  70. Grassi FR, Rapone B, Scarano Catanzaro F, Corsalini M, Kalemaj Z. Effectiveness of computer-assisted anesthetic delivery system (STATM) in dental implant surgery: a prospective study. *Oral Implantology* 2017; 10:381–389.
  71. Charitos IA, Ballini A, Bottalico L, Cantore S, Passarelli PC, Inchingolo F, D'Addona A, Santacroce L. Special features of SARS-CoV-2 in daily practice. *World J Clin Cases.* 2020; 8 (18):3920–3933.
  72. Ballini A, Cantore S, Scacco S, et al. A comparative study on different stemness gene expression between dental pulp stem cells vs. dental bud stem cells. *Eur Rev Med Pharmacol Sci.* 2019; 23 (4):1626–1633.
  73. Cantore S, Ballini A, De Vito D, et al. Characterization of human apical papilla-derived stem cells. *J Biol Regul Homeost Agents.* 2017; 31 (4):901–910.
  74. Montemurro N, Perrini P. Will COVID-19 change neurosurgical clinical practice? *Br J Neurosurg.* 2020; 1:1–2.
  75. Rapone B, Ferrara E, Corsalini M, Qorri E, Converti I, Lorusso F, Delvecchio M, Gnoni A, Scacco S, Scarano A. Inflammatory Status and Glycemic Control Level of Patients with Type 2 Diabetes and Periodontitis: A Randomized Clinical Trial. *Int J Environ Res Public Health* 2021 Mar 15; 18(6):3018.
  76. Montemurro N, Benet A, Lawton MT. Clipping of Ruptured Residual Anterior Communicating Artery Aneurysm After Endovascular Coiling: 3-Dimensional Operative Video. *Oper Neurosurg (Hagerstown).* 2016; 12 (1):93–94.
  77. Di Comite M, Crincoli V, Fatone L, Ballini A, et al. Quantitative analysis of defects at the dentin-

- post space in endodontically treated teeth. *Materials* 2015; 8,3268-3283.
78. Rapone B, Palmisano C, Ferrara E, Di Venere D, Albanese G, Corsalini M. The Accuracy of Three Intraoral Scanners in the Oral Environment with and without Saliva: A Comparative Study. *Appl. Sci.* 2020; 10, 7762.
  79. Lorusso F, Postiglione F, Delvecchio M, Rapone B., Scarano A. The impact of diabetes on implant oral rehabilitations: a bibliometric study and literature review. *Acta Medica Mediterranea* 2020; 36: 3333.
  80. Pham VH, Gargiulo Isacco C, Nguyen KCD, et al. Rapid and sensitive diagnostic procedure for multiple detection of pandemic Coronaviridae family members SARS-CoV-2, SARS-CoV, MERS-CoV and HCoV: a translational research and cooperation between the Phan Chau Trinh University in Vietnam and University of Bari "Aldo Moro" in Italy. *Eur Rev Med Pharmacol Sci.* 2020; 24 (12):7173-7191.
  81. Bordea IR, Xhajanka E, Candrea S, Bran S, Onișor F, Inchingolo AD, et al. Coronavirus (SARS-CoV-2) Pandemic: Future Challenges for Dental Practitioners. *Microorganisms.* 2020; 8 (11):1704.
  82. Santacroce L, Inchingolo F, Topi S, Del Prete R, Di Cosola M, Charitos IA, Montagnani M. Potential beneficial role of probiotics on the outcome of COVID-19 patients: An evolving perspective. *Diabetes Metab Syndr.* 2021; 15 (1):295-301.
  83. Inchingolo F, Tatullo M, Abenavoli FM, Marrelli M, Inchingolo AD, Inchingolo AM, Dipalma G. Comparison between traditional surgery, CO2 and Nd:Yag laser treatment for generalized gingival hyperplasia in Sturge-Weber syndrome: a retrospective study. *J Investig Clin Dent.* 2010; 1 (2):85-89.
  84. Dang QT, Huynh TD, Inchingolo F, Dipalma G, Inchingolo AD, et al. Human Chondrocytes from Human Adipose Tissue-Derived Mesenchymal Stem Cells Seeded on a Dermal-Derived Collagen Matrix Sheet: Our Preliminary Results for a Ready to Go Biotechnological Cartilage Graft in Clinical Practice. *Stem Cells Int.* 2021; 2021:6664697.
  85. Ballini A, Cantore S, Signorini L, Saini R, Scacco S, Gnoni A, Inchingolo AD, et al. Efficacy of Sea Salt-Based Mouthwash and Xylitol in Improving Oral Hygiene among Adolescent Population: A Pilot Study. *Int J Environ Res Public Health.* 2020; 18 (1):44.
  86. Adina S, Dipalma G, Bordea IR, Lucaciu O, Feurdean C, Inchingolo AD, et al. Orthopedic joint stability influences growth and maxillary development: clinical aspects. *J Biol Regul Homeost Agents.* 2020; 34 (3):747-756.
  87. Heiland M, Habermann CR, Schmelzle R. Indications and limitations of intraoperative navigation in maxillofacial surgery. *J Oral Maxillofac Surg.* 2004; 62 (9):1059-63.
  88. Landaeta-Quinones CG, Hernandez N, Zarroug NK. Computer-Assisted Surgery: Applications in Dentistry and Oral and Maxillofacial Surgery. *Dent Clin North Am.* 2018; 62 (3):403-420.
  89. Hohlweg-Majert B, Schön R, Schmelzisen R, Gellrich NC, Schramm A. Navigational maxillofacial surgery using virtual models. *World J Surg.* 2005; 29 (12):1530-8.
  90. Wu B, Wei T, Yao Z, Yang S, Yao Y, Fu C, Xu F, Xiong C. A real-time 3D electromagnetic navigation system for percutaneous transforaminal endoscopic discectomy in patients with lumbar disc herniation: a retrospective study. *BMC Musculoskelet Disord.* 2022; 23 (1):57.
  91. Ahsan K, Khan SI, Zaman N, Ahmed N, Montemurro N, Chaurasia B. Fusion versus nonfusion treatment for recurrent lumbar disc herniation. *J Craniovertebr Junction Spine.* 2021; 12 (1):44-53.
  92. Montemurro N, Perrini P, Mangini V, Galli M, Papini A. The Y-shaped trabecular bone structure in the odontoid process of the axis: a CT scan study in 54 healthy subjects and biomechanical considerations. *J Neurosurg Spine.* 2019; 1:1-8.
  93. Ahsan MK, Hossain MR, Khan MSI, et al. Lumbar revision microdiscectomy in patients with recurrent lumbar disc herniation: A single-center prospective series. *Surg Neurol Int.* 2020; 11:404.
  94. Canseco JA, Schroeder GD, Paziuk TM, et al. The Subaxial Cervical AO Spine Injury Score. *Global Spine J.* 2020; 11:2192568220974339.
  95. Perrini P, Montemurro N. Congenital absence of a cervical spine pedicle. *Neurol India.* 2016; 64 (1):189-190. Schroeder GD, Canseco JA, Patel PD, et al. Establishing the Injury Severity of Subaxial Cervical Spine Trauma: Validating the Hierarchical Nature of the AO Spine Subaxial Cervical Spine Injury Classification System. *Spine (Phila Pa 1976).*

- 2021; 46 (10):649-657.
96. Perrini P, Gambacciani C, Martini C, Montemurro N, Lepori P. Anterior cervical corpectomy for cervical spondylotic myelopathy: Reconstruction with expandable cylindrical cage versus iliac crest autograft. A retrospective study. *Clin Neurol Neurosurg.* 2015; 139:258-263.
  97. Islam MA, Afreen MS, Montemurro N, Chaurasia B. Surgical Approach for Spinal Tumors: Our Experience in Combined Military Hospital Dhaka. *Surgeries.* 2021; 2 (3):303-307.
  98. Canseco JA, Schroeder GD, Patel PD, et al. Regional and experiential differences in surgeon preference for the treatment of cervical facet injuries: a case study survey with the AO Spine Cervical Classification Validation Group. *Eur Spine J.* 2021; 30 (2):517-523.
  99. Montemurro N, Ortenzi V, Naccarato GA, Perrini P. Angioleiomyoma of the knee: An uncommon cause of leg pain. A systematic review of the literature. *Interdiscip. Neurosurg.* 2020; 22:100877.
  100. Wolfgang S, Josef Z. *Neuronavigation and Neuroanatomy.* Freiburg: Springer-Verlag Wien; 2002: 3-6.
  101. Yu H, Shen SG, Wang X, Zhang L, Zhang S. The indication and application of computer-assisted navigation in oral and maxillofacial surgery-Shanghai's experience based on 104 cases. *J Craniomaxillofac Surg.* 2013; 41 (8):770-774.
  102. Pham VH, Gargiulo Isacco C, Nguyen KCD, et al. Rapid and sensitive diagnostic procedure for multiple detection of pandemic Coronaviridae family members SARS-CoV-2, SARS-CoV, MERS-CoV and HCoV: a translational research and cooperation between the Phan Chau Trinh University in Vietnam and University of Bari "Aldo Moro" in Italy. *Eur Rev Med Pharmacol Sci.* 2020; 24 (12):7173-7191.
  103. Farronato, M.; Farronato, D.; Inchingolo, F.; Grassi, L.; Lanteri, V.; Maspero, C. Evaluation of Dental Surface after De-Bonding Orthodontic Bracket Bonded with a Novel Fluorescent Composite: In Vitro Comparative Study. *Appl. Sci.* 2021, 11, 6354, doi:10.3390/app11146354.
  104. Cardarelli, F.; Patano, A.; Montenegro, V.; Malcangi, G.; Coloccia, G.; Inchingolo, A.D.; Marinelli, G.; Laudadio, C.; Dipalma, G.; Di Venere, D.; Inchingolo, F. Elastodontic therapy un nuovo approccio alla terapia ortodontica funzionale. *Il Dentista Moderno* 2021, 48-63
  105. Inchingolo, F.; Tatullo, M.; Marrelli, M.; Inchingolo, A.M.; Tarullo, A.; Inchingolo, A.D.; Dipalma, G.; Brunetti, S.P.; Tarullo, A.; Cagiano, R. Combined Occlusal and Pharmacological Therapy in the Treatment of Temporo-Mandibular Disorders. *Eur. Rev. Med. Pharmacol. Sci.* 2011, 15, 1296-1300.
  106. Topi S, Santacroce L, Bottalico L, Ballini A, Inchingolo AD, Dipalma G, Charitos IA, Inchingolo F. Gastric Cancer in History: A Perspective Interdisciplinary Study. *Cancers (Basel).* 2020 Jan 22;12(2):264. doi: 10.3390/cancers12020264.
  107. Boccellino M, Di Stasio D, Dipalma G, Cantore S, Ambrosio P, Coppola M, Quagliuolo L, Scarano A, Malcangi G, Borsani E, Rinaldi B, Nuzzolese M, Xhajanka E, Ballini A, Inchingolo F, Di Domenico M. Steroids and growth factors in oral squamous cell carcinoma: useful source of dental-derived stem cells to develop a steroidogenic model in new clinical strategies. *Eur Rev Med Pharmacol Sci.* 2019 Oct;23(20):8730-8740. doi: 10.26355/eurrev\_201910\_19267.
  108. Vermesan D, Inchingolo F, Patrascu JM, Trocan I, Prejbeanu R, Florescu S, Damian G, Benagianu V, Abbinante A, Caprio M, Cagiano R, Haragus H. Anterior cruciate ligament reconstruction and determination of tunnel size and graft obliquity. *Eur Rev Med Pharmacol Sci.* 2015;19(3):357-64.
  109. Inchingolo F, Tatullo M, Abenavoli FM, Marrelli M, Inchingolo AD, Corelli R, Inchingolo AM, Dipalma G. Upper eyelid reconstruction: a short report of an eyelid defect following a thermal burn. *Head Face Med.* 2009 Nov 25;5:26. doi: 10.1186/1746-160X-5-26.
  110. Inchingolo F, Pacifici A, Gargari M, Acitores Garcia JI, Amantea M, Marrelli M, Dipalma G, Inchingolo AM, Rinaldi R, Inchingolo AD, Pacifici L, Tatullo M. CHARGE syndrome: an overview on dental and maxillofacial features. *Eur Rev Med Pharmacol Sci.* 2014;18(15):2089-93.
  111. Inchingolo F, Tatullo M, Abenavoli FM, Inchingolo AD, Inchingolo AM, Dipalma G. Fish-hook injuries: a risk for fishermen. *Head Face Med.* 2010 Dec 14;6:28. doi: 10.1186/1746-160X-6-28.
  112. Fanali S, Tumedei M, Pignatelli P, Inchingolo F, Pennacchietti P, Pace G, Piattelli A. Implant primary



- stability with an osteocondensation drilling protocol in different density polyurethane blocks. *Comput Methods Biomech Biomed Engin.* 2021 Jan;24(1):14-20. doi: 10.1080/10255842.2020.1806251.
113. Dohan Ehrenfest, D.M., Del Corso, M., Inchingolo, F., Charrier, J.-B. Selecting a relevant in vitro cell model for testing and comparing the effects of a Choukroun's platelet-rich fibrin (PRF) membrane and a platelet-rich plasma (PRP) gel: Tricks and traps. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology*, 2010, 110(4), pp. 409–411.
114. Inchingolo F, Tatullo M, Marrelli M, Inchingolo AD, Corelli R, Inchingolo AM, Dipalma G, Abenavoli FM. Clinical case-study describing the use of skin-perichondrium-cartilage graft from the auricular concha to cover large defects of the nose. *Head Face Med.* 2012 Mar 19;8:10. doi: 10.1186/1746-160X-8-10.
115. Inchingolo F, Tatullo M, Abenavoli FM, Marrelli M, Inchingolo AD, Servili A, Inchingolo AM, Dipalma G. A hypothetical correlation between hyaluronic acid gel and development of cutaneous metaplastic synovial cyst. *Head Face Med.* 2010 Jul 15;6:13. doi: 10.1186/1746-160X-6-13.
116. Goldoni R, Dolci C, Boccalari E, Inchingolo F, Paghi A, Strambini L, Galimberti D, Tartaglia GM. Salivary biomarkers of neurodegenerative and demyelinating diseases and biosensors for their detection. *Ageing Res Rev.* 2022 Apr;76:101587. doi: 10.1016/j.arr.2022.101587.
117. Ceratti C, Maspero C, Consonni D, Caprioglio A, Connelly ST, Inchingolo F, Tartaglia GM. Cone-Beam Computed Tomographic Assessment of the Mandibular Condylar Volume in Different Skeletal Patterns: A Retrospective Study in Adult Patients. *Bioengineering (Basel).* 2022 Mar 2;9(3):102.
118. Maspero C, Cappella A, Dolci C, Cagetti MG, Inchingolo F, Sforza C. Is Orthodontic Treatment with Microperforations Worth It? A Scoping Review. *Children (Basel).* 2022 Feb 6;9(2):208.
119. Cantore, S., Ballini, A., De Vito, D., et al. Clinical results of improvement in periodontal condition by administration of oral Probiotics. *Journal of Biological Regulators and Homeostatic Agents*, 2018, 32(5), pp. 1329–1334.
120. Rapone B, Pedone S, Carnevale A, Plantamura P, Scarano A, Demelio A, Demelio GP, Corsalini M. Profilometer Comparison of the Surface Roughness of Four Denture Base Resins: An In Vitro Study. *Applied Sciences.* 2022; 12(4):1837. <https://doi.org/10.3390/app12041837>.
121. Malcangi G, Inchingolo AD, Inchingolo AM, Piras F, Settanni V, Garofoli G, Palmieri G, Ceci S, Patano A, Mancini A, Vimercati L, Nemore D, Scardapane A, Rapone B, Semjonova A, D'Oria MT, Macchia L, Bordea IR, Migliore G, Scarano A, Lorusso F, Tartaglia GM, Giovanniello D, Nucci L, Maggialetti N, Parisi A, Domenico MD, Brienza N, Tafuri S, Stefanizzi P, Curatoli L, Corriero A, Contaldo M, Inchingolo F, Dipalma G. COVID-19 Infection in Children and Infants: Current Status on Therapies and Vaccines. *Children.* 2022; 9(2):249. <https://doi.org/10.3390/children9020249>.
122. Malcangi G, Inchingolo AD, Patano A, Coloccia G, Ceci S, Garibaldi M, Inchingolo AM, Piras F, Cardarelli F, Settanni V, Rapone B, Corriero A, Mancini A, Corsalini M, Nucci L, Bordea IR, Lorusso F, Scarano A, Giovanniello D, Dipalma G, Posa VM, Di Venere D, Inchingolo F. Impacted Central Incisors in the Upper Jaw in an Adolescent Patient: Orthodontic-Surgical Treatment-A Case Report. *Applied Sciences.* 2022; 12(5):2657. <https://doi.org/10.3390/app12052657>.
123. Di Venere D, Rapone B, Corsalini M. Dental trauma in the anterior sector: an analysis of the predisposing factors in a group of orthodontic patients. *Clinica Terapeutica* 2020, 171 (6):e481-485. doi: 10.7417/CT.2020.2261.
124. Nardi G.M., Ferrara E., Converti I., Cesarano F., Scacco S., Grassi R., Gnoni A., Grassi F.R., Rapone B. Does Diabetes Induce the Vascular Endothelial Growth Factor (VEGF) Expression in Periodontal Tissues? A Systematic Review. *Int. J. Environ. Res. Public Health* 2020, 17(8), 2765. doi: 10.3390/ijerph17082765.
125. Di Venere D, Nardi GM, Lacarbonara V, Laforgia A, Stefanachi G, Corsalini M, Grassi FR, Rapone B, Pettini F. Early mandibular canine-lateral incisor transposition: Case Report. *Oral Implantology* 2017 April; 10(2):181-189. doi: 10.11138/orl/2017.10.2.181.

126. Inchingolo, A.D.; Ceci, S.; Patano, A.; Inchingolo, A.M.; Montenegro, V.; Di Pede, C.; Malcangi, G.; Marinelli, G.; Coloccia, G.; Garibaldi, M.; Kruti, Z.; Palmieri, G.; De Leonardis, N.; Rapone, B.; Mancini, A.; Semjonova, A.; Nucci, L.; Bordea, I.R.; Scarano, A.; Lorusso, F.; Ferrara, E.; Farronato, M.; Tartaglia, G.M.; Di Venere, D.; Cardarelli, F.; Inchingolo, F.; Dipalma, G. Elastodontic Therapy of Hyperdivergent Class II Patients Using AMCOP® Devices: A Retrospective Study. *Appl. Sci.* 2022, 12, 3259. doi: 10.3390/app12073259
127. Di Naro E, Loverro M, Converti I, Loverro MT, Ferrara E, Rapone B. The Effect of Menopause Hypoestrogenism on Osteogenic Differentiation of Periodontal Ligament Cells (PDLC) and Stem Cells (PDLCs): A Systematic Review. *Healthcare (Basel)*. 2021 May 12;9(5):572. doi: 10.3390/healthcare9050572.
128. Mavriqi L, Lorusso F, Conte R, Rapone B, Scarano A. Zygomatic implant penetration to the central portion of orbit: a case report. *BMC Ophthalmol*. 2021, 21(1):121. doi: 10.1186/s12886-021-01846-1.
129. Corsalini M, Rapone B, Cagnetta G, Carossa M, Sportelli P, De Giacomo A, Laforgia A, Di Venere D. Orofacial functions and chewing efficiency in elderly patients with Parkinson's disease rehabilitated with removable prostheses. *The Open Dentistry* 2020, 14:13-18. doi: 10.2174/1874210602014010013.
130. Scarano A, Rapone B, Amuso D, Inchingolo F, Lorusso F. Hyaluronic Acid Fillers Enriched with Glycine and Proline in Eyebrow Augmentation Procedure. *Aesthetic Plast Surg*. 2022 Feb;46(1):419-428. doi: 10.1007/s00266-021-02412-2.
131. Scarano A., Inchingolo F., Rapone B., Lucchina A.G., Qorri E., Lorusso F. Role of Autologous Platelet Gel (APG) in Bone Healing: A Rabbit Study. *Appl. Sci.* 2021, 11, 395. doi: 10.3390/app11010395.
132. Delvecchio M, Rapone B, Simonetti S, Fecarotta S, De Carlo G, Favoino E, Loverro MT, Romano AMI, Taurino F, Di Naro E, Gnoni A. Dietary cholesterol supplementation and inhibitory factor 1 serum levels in two dizygotic Smith-Lemli-Opitz syndrome twins: a case report. *Ital J Pediatr*. 2020 Oct 28;46(1):161. doi: 10.1186/s13052-020-00924-2.
133. Corsalini M, Rapone B, Grassi FR, Di Venere D. A study on oral rehabilitation in stroke patients: analysis of a group of 33 patients. *Gerodontology*. 2010 Sep;27(3):178-82. doi: 10.1111/j.1741-2358.2009.00322.x.
134. Kalemaj Z, Scarano A, Valbonetti L, Rapone B, Grassi FR. Bone Response to Four Dental Implants with Different Surface Topographies: A Histologic and Histometric Study in Minipigs. *Int J Periodontics Restorative Dent*. 2016 Sep-Oct;36(5):745-54. doi: 10.11607/prd.2719.
135. Rapone B, Inchingolo AD, Trasarti S, Ferrara E, Qorri E, Mancini A, Montemurro N, Scarano A, Inchingolo AM, Dipalma G, Inchingolo F. Long-Term Outcomes of Implants Placed in Maxillary Sinus Floor Augmentation with Porous Fluorohydroxyapatite (Algipore® FRIOS®) in Comparison with Anorganic Bovine Bone (Bio-Oss®) and Platelet Rich Plasma (PRP): A Retrospective Study. *Journal of Clinical Medicine*. 2022; 11(9):2491.
136. Inchingolo AD, Patano A, Coloccia G, Ceci S, Inchingolo AM, Marinelli G, Malcangi G, Di Pede C, Garibaldi M, Ciocia AM, Mancini A, Palmieri G, Rapone B, Piras F, Cardarelli F, Nucci L, Bordea IR, Scarano A, Lorusso F, Giovanniello D, Costa S, Tartaglia GM, Di Venere D, Dipalma G, Inchingolo F. Treatment of Class III Malocclusion and Anterior Crossbite with Aligners: A Case Report. *Medicina*. 2022; 58(5):603.
137. Inchingolo AD, Malcangi G, Inchingolo AM, Piras F, Settanni V, Garofoli G, Palmieri G, Ceci S, Patano A, De Leonardis N, Di Pede C, Montenegro V, Azzollini D, Garibaldi MG, Kruti Z, Tarullo A, Coloccia G, Mancini A, Rapone B et al. Benefits and Implications of Resveratrol Supplementation on Microbiota Modulations: A Systematic Review of the Literature. *International Journal of Molecular Sciences*. 2022; 23(7):4027.
138. Lorusso, F.; Postiglione, F.; Delvecchio, M.; Rapone, B.; Scarano, A. The impact of diabetes in implant oral rehabilitations: A bibliometric study and literature review. *Acta Med. Mediterr.* 2020, 36, 3333.