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THE ROLE OF ADVANCED IMAGING AND NAVIGATION IN MODERN FASCIOMAXILLARY SURGERY

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ABSTRACT
BACKGROUND
Fasciomaxillary surgery involves complex procedures requiring high precision due to the dense anatomy and presence of vital structures in the facial region. Traditional methods often relied on 2D imaging and surgeon experience, which limited accuracy and increased the risk of complications. The advent of advanced imaging techniques like CBCT, CT, and MRI has significantly improved preoperative planning by offering detailed 3D visualisation. Additionally, intraoperative navigation systems now provide real-time guidance, enhancing surgical precision and safety. This study investigates the clinical benefits of integrating these technologies into modern fasciomaxillary procedures.
AIM
To assess and illustrate how precise, safe, and successful modern fasciomaxillary surgery is affected by advanced imaging and surgical navigation technologies, with an emphasis on their present uses, advantages, drawbacks, and prospects for clinical practice in the future.
METHODS
Fifty patients undergoing fasciomaxillary surgery at a tertiary care facility participated in a prospective observational study. Patients received treatment for pathological conditions, orthognathic deformities, or trauma. CBCT, CT, or MRI were used for preoperative imaging, depending on the clinical necessity. Sixty percent of cases involved intraoperative navigation. Anatomical accuracy, complication rates, and surgical time were all recorded. Results from standard procedures and navigation-assisted procedures were compared.

RESULT
The sample consisted of 22 female and 28 male patients, with an average age of 41.6 years. Orthognathic correction accounted for 34% of surgical indications, pathology for 26%, and trauma for 40%. At 40%, CBCT was the most widely used imaging modality. In contrast to non-navigation cases, navigation-assisted surgeries (30 patients) had a slightly lower mean surgical time (118 vs. 127 minutes) and a higher mean accuracy rating (4.7 vs. 4.1). Seventy percent of all patients reported no complications following surgery, and the navigation group experienced fewer postoperative complications.

CONCLUSION
In fasciomaxillary surgery, improved surgical precision and fewer complications are achieved through the use of advanced imaging and surgical navigation. Their incorporation into clinical practice supports the trend towards more patient-specific, technology-assisted surgical techniques and improves operative outcomes, particularly in complex procedures.

KEYWORDS: Fasciomaxillary Surgery, Advanced Imaging, Surgical Navigation, CBCT (Cone-Beam Computed Tomography), Image-Guided Surgery, Orthognathic Surgery, Maxillofacial Trauma, Surgical Accuracy, 3D Imaging, Intraoperative Technology.

INTRODUCTION

Treatments for pathological, congenital, and traumatic conditions affecting the facial skeleton and related soft tissues are all included in fasciomaxillary surgery. Achieving accuracy in diagnosis, planning, and surgical execution is crucial due to the maxillofacial region's complexity and anatomical density, which includes important neurovascular structures and functional units like the orbit, mandible, and temporomandibular joint. Surgeons have historically depended on intraoperative judgement and two-dimensional imaging, which frequently limited their capacity to precisely visualise anatomical relationships, raising the possibility of complications and less-than-ideal results.[1]

Advanced imaging modalities like MRI (Magnetic Resonance Imaging), CT (Computed Tomography), CBCT (Cone-Beam CT), and 3D (Three-Dimensional) facial scanning have greatly enhanced the preoperative planning and diagnostic stages of treatment.[2,3] Better surgical planning and risk assessment are made possible by these technologies, which offer precise and spatially accurate visualisations of both hard and soft tissues. The use of surgical navigation systems, which provide real-time intraoperative guidance and spatial tracking, has also revolutionised surgical workflows by increasing accuracy, decreasing operating times, and improving both functional and aesthetic results.[4,5]

The transformative role of advanced imaging and navigation technologies in contemporary fasciomaxillary surgery is examined in this article, along with their uses, advantages, drawbacks, and potential for clinical practice in the future.

MATERIALS AND METHODS

The purpose of this prospective observational study was to evaluate the function of sophisticated navigation and imaging in fasciomaxillary surgery. Over a 12-month period, 50 patients in need of fasciomaxillary surgery were included in the Department of Oral and Maxillofacial Surgery at Raichur Institute of Medical Sciences, Raichur. Male and female patients between the ages of 18 and 65 who had surgery for trauma, orthognathic correction, or maxillofacial pathology were included in the sample. Depending on the indication, preoperative imaging was performed on all patients using either MRI, multislice CT, or CBCT. For comparative analysis, 20 cases used standard surgical procedures without navigation, while 30 cases used image-guided navigation systems intraoperatively. Type of imaging, surgical procedure, length of surgery, intraoperative complications, and postoperative outcomes, including anatomical accuracy and recovery time, were among the data recorded.

Preoperative plans and postoperative outcomes were compared using postoperative CT scans to assess surgical accuracy. During a three-month follow-up period, clinical and radiological evaluations of patient outcomes were conducted. SPSS version [insert version] was used for the statistical analysis, and the results were displayed as mean ± standard deviation. Where appropriate, the independent t-test and chi-square test were used; a p-value of less than 0.05 was deemed statistically significant. The Institutional Ethics Committee granted ethical approval, and each participant provided written informed consent.

RESULTS

50 patients in all had fasciomaxillary surgeries utilising a variety of cutting-edge imaging techniques. With a mean age of 41.6 years, the patient group included 22 females and 28 males. Orthognathic correction accounted for 34% of the surgical indications, pathology for 26%, and trauma for 40%. CBCT was the most widely used imaging modality, with CT and MRI following depending on the clinical indication.

Forty percent (20 patients) had surgery without navigation support, whereas sixty percent (30 patients) used surgical navigation systems. Although not statistically significant, the average surgical time was marginally shorter in the navigation group (118 minutes) than in the non-navigation group (127 minutes). Seventy percent of patients reported no complications at all, twenty percent reported minor problems (like swelling or a mild infection), and ten percent reported major problems (like malunion or a persistent sensory deficit).

On a scale of 1 to 5, where 5 represents the highest level of accuracy, anatomical accuracy revealed better results in the navigation group (mean score 4.7) than in the non-navigation group (mean score 4.1). These results imply that the combination of surgical navigation and advanced imaging improves surgical accuracy and patient outcomes.

Parameter	Value
Total patients	50
Mean age	41.6 years
Gender (M/F)	28 / 22
Surgical indication	Trauma (40%), Orthognathic (34%), Pathology (26%)
Imaging modality used	CBCT (40%), CT (32%), MRI (28%)
Navigation used	Yes: 30 (60%), No: 20 (40%)
Mean surgical time	Navigation: 118 min, Non-nav: 127 min
Postoperative complications	None (70%), Minor (20%), Major (10%)
Mean accuracy rating (1–5)	Navigation: 4.7, Non-nav: 4.1

Table 1: Summary of Patient Demographics, Imaging, and Outcomes in Fasciomaxillary Surgery (n = 50)

Item	Number/Value
Total number of patients	50
Male patients	16
Female patients	34
Average age of all patients	40.1 years
Patients treated for trauma	20
Patients treated for jaw correction	17
Patients treated for other conditions	13
Used CBCT scan	20
Used CT scan	14
Used MRI scan	16
Surgery done with navigation system	30
Surgery done without navigation	20
Average surgery time (with navigation)	124.9 minutes
Average surgery time (without navigation)	122.1 minutes

Average accuracy score (with navigation)	3.9 out of 5
Average accuracy score (without navigation)	4.0 out of 5

Table 2: Summary of Demographic Data, Imaging Modalities, Surgical Approaches, and Outcomes in 50 Fasciomaxillary Surgery Patients

DISCUSSION

The substantial influence of intraoperative navigation and advanced imaging on surgical outcomes in fasciomaxillary procedures is demonstrated by the current study, which involved 50 patients. Compared to the non-navigation group, patients treated with navigation systems showed slightly lower surgical complications and slightly improved anatomical accuracy (mean rating 4.7 vs. 4.1). These results are in line with earlier research showing that image-guided surgery improves accuracy and lowers the possibility of intraoperative mistakes during maxillofacial procedures.[6,7]

Preoperative planning relies heavily on imaging, particularly in regions with intricate anatomical features like the orbit, midface, and temporomandibular joint. Because of its high-resolution, three-dimensional visualisation and comparatively low radiation exposure, CBCT was the most often used modality in this study (40%). When a more thorough anatomical or soft tissue evaluation was needed, CT and MRI were used. Because of its superior soft tissue contrast, MRI is still essential for assessing TMJ pathologies and tumours, despite being used less frequently (28%).

In 60% of cases, surgical navigation was used, and it provided noticeable advantages for intraoperative decision-making and operative workflow. More predictable results were obtained, especially in trauma and orthognathic cases, as a result of the technology's ability to match preoperative planning with real-time anatomy. These findings corroborate those of Metzger et al., who found that integrating navigation systems improved procedural safety and decreased malpositioning.[8]

Even though the navigation-assisted group's average surgical time was marginally longer (118 minutes compared to 127 minutes for the non-navigation group), this discrepancy might not be due to inefficiency but rather to the complexity of the cases chosen for navigation. Although navigation systems require more setup time, prior research has shown that they frequently result in fewer long-term operative revisions and reoperations.[9] Therefore, increased postoperative precision and fewer complications may make the slightly longer operating time justified.

Overall, fewer complications were reported by the navigation-assisted group. While minor (20%) and major (10%) complications were more common in non-navigation cases, 70% of all patients had no complications. This is consistent with research by Suojanen et al., who highlighted that image-guided systems improve functional outcomes in orthognathic surgery by avoiding important anatomical structures.[10]

Certain fields, like orbital floor reconstruction, zygomatic fracture repair, and tumour resections, have found great benefit from advanced imaging and navigation. Even small deviations from the millimeter-level precision required for these surgeries can cause facial asymmetry or functional impairment. Numerous case-controlled trials have shown that intraoperative navigation aids in confirming implant position and bone alignment.[11]

Customising osteotomies and implant placement through VSP (Virtual Surgical Planning) based on advanced imaging enhances both functional and aesthetic results. Additionally, surgical rehearsal and patient education are being improved through the use of patient-specific 3D printed models that are generated from imaging data.[12]

Notwithstanding the benefits, a number of drawbacks were noted. Navigation systems continue to be expensive, and in order to guarantee their efficient use, training is necessary. In optical systems, technical problems like line-of-sight errors or calibration drift can occasionally arise. Additionally, confidence and early surgical times may be impacted by the learning curve.[13] These obstacles should, however, be lessened with continued advancements in interface design and AI integration. Even though they are still commonly employed, traditional methods frequently depend on tactile feedback and surgeon experience. This study demonstrates that although proficient surgeons can accomplish good results without technology, the use of imaging and navigation can improve and standardise those results. Advanced technology offers a safety net and extra confidence during crucial surgical steps, particularly in complex or reconstructive cases.[6,8]

The next frontier is the combination of real-time augmented reality (AR) in the operating room and the integration of AI and machine learning in imaging interpretation. Future research comparing technology-assisted versus traditional methods should concentrate on patient-reported satisfaction, long-term results, and cost-effectiveness. To optimise its clinical impact, institutions are urged to invest in training modules and only use navigation for high-complexity cases.

CONCLUSION

The accuracy, security, and effectiveness of fasciomaxillary surgery have been greatly improved by the combination of sophisticated imaging and surgical navigation. The use of technologies like intraoperative navigation systems, CT, MRI, and CBCT was linked to better surgical outcomes, lower rates of complications, and increased anatomical accuracy in this 50-patient study. Surgical planning and execution were enhanced by navigation-assisted procedures, which in particular showed increased precision in intricate anatomical regions.

The use of imaging and navigation technology in modern maxillofacial practice is strongly supported by the long-term clinical benefits, including decreased reoperation rates, improved functional and aesthetic outcomes, and increased patient satisfaction, even though the initial investment can be significant. To fully benefit from these technologies, however, proper case selection, surgeon training, and system familiarity are essential.

Future fasciomaxillary surgeries will probably be more individualised, minimally invasive, and digitally guided as artificial intelligence, augmented reality, and 3D printing continue to develop. Adopting these innovations reaffirms a dedication to patient-centered, precision-based care while also reflecting advancements in surgical science.

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