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Original Research

Evaluation of one-point fixation for zygomaticomaxillary complex fractures using a three-dimensional photogrammetric analysis

S Senthilnathan[1], Dayanithi B.S[2], Ashutosh Pundlik Dod[3], Rummaan Ahmed Sheikh[4], Shreshth Sharma[5], Nitin kaushik[6]

1. MDS, Assistant Professor, Dept Of Dentistry, Meeenakshi Medical College Hospital And Research Institute, Kanchipuram
2. Assistant professor, Oral & Maxillofacial Surgeon, Meenakshi medical college & research institute, Kanchipuram
3. 3rd year Post graduate, Dept. Of Oral and Maxillofacial Surgery MIDSR Latur, Maharashtra
4. MDS Senior Lecturer, Index Institute of Dental Sciences, Indore, 41 Radio Colony Residency Area , Indore
5. B.D.S, M.D.S, Oral and maxillofacial surgery, Bhopal, Madhya Pradesh
6. MDS - Periodontology. Associated with Clove dental as Consultant Periodontist and Implantologist, Amrawati Enclave, Panchkula

***ABSTRACT*:**

Aim: The purpose of our study was to assess the stability of one-point fixation using a three-dimensional photogrammetric analysis. **Methodology:** 10 patients with ZMC fractures were treated by one-point fixation in the ZM buttress using unsintered hydroxyapatite (u-HA)/poly-L-lactide (PLLA) plates. Differences in soft tissue intermalar height between the fractured side and unfractured sides were evaluated using photogrammetric analysis with a three-dimensional camera (Morphius®) at the preoperative and 1 week, 1 and 3 months after surgery. The differences in bony inter-malar height between the fractured and unfractured sides were evaluated using computer tomography at the pre-operative and 6 months after surgery. The paired t-test was used to compare differences in malar height. **Results:** Six months after surgery, 10 patients achieved satisfactory bony stability and symmetric malar appearances. Comparisons of differences in soft-tissue inter-malar height revealed statistically significant differences between the pre-operative period and 1 week and 1 month after surgery ($p < .01$). There was no statistically significant difference between 1 and 3months after surgery. Comparison of differences in bony inter-malar height revealed a statistically significant difference between before and 6 months after surgery ($p < .01$). **Conclusion:** When we conducted a three-dimensional photogrammetric analysis, although it has restricted surgical indications, one-point fixation of the ZM buttress using a u-HA / PLLA plate yielded safe clinical results in patients with ZMC fractures.

Keywords: Zygomaticomaxillary complex fracture, Zygomaticomaxillary buttress, One-point fixation, Three-dimensional photogrammetric analysis

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Corresponding Author: S Senthilnathan MDS, Assistant Professor, Dept Of Dentistry, Meeenakshi Medical College Hospital And Research Institute, Kanchipuram

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INTRODUCTION

Facial appearance affects the foundation of an individual's personality, and facial change due to injury can cause harmful alteration in one's sense of self and how one interacts and expresses oneself in society.[1] The zygomatic bone is the most prominent and characteristic in the midface, [2] and its traumatic fracture may lead to crucial deformity of the face. [3] It is essential to restore the bony structure of the zygoma to its original shape.

The primary goals in the treatment of zygomatic fractures include the restoration of the projection and the height of the zygoma by accurate reduction and the restoration of the aesthetic appearance. Adequate

exposure and reduction by multiple incisions and strong fixation by plates are believed to be essential to achieving satisfactory results. However, these conventional approaches require a long operation time and may lead to unnecessary scarring. To overcome these limitations, several new at tempts have been made in the management of zygomatic fractures.[4] Previous studies on the appearance of zygomatic fractures were limited to reporting the rates of gross complications such as lower lid retractions, ectropions, and entropions. Smaller changes to the periorbital structures were neglected. Moreover, previous studies on the stability of zygomatic fractures primarily involved experiments on cadaveric heads,[5] and did not correspond with the actual clinical situations.[6] The recent widespread use of three-dimensional computed tomography (3D CT) made it easier to verify the position and displacement of the zygomatic body *in vivo*. Consequently, less aggressive methods to obtain stability were developed.[7] The standard treatment for zygomaticomaxillary complex (ZMC) fracture has been open reduction and internal fixation (ORIF),[8] and sites of one-, two-, or three-point fixation are selected based on stability of the fractured zygoma.[9] Among fixation sites, the zygomaticofrontal (ZF) suture followed by zygomaticosphenoidal (ZS) suture has been the single most reliable site for anatomical alignment and secure fixation.[10] Thus, this site has been the primary location of fixation even in 1- point fixation.[11] However, the ORIF approach of ZF suture through a lateral eyebrow incision may leave visible scars, uncomfortable palpability of plates on thin skin, and risk of drill penetration into the anterior cranial fossa.[12] Recently, the main concern of patients who experience zygomatic fractures is whether they can recover an aesthetically pleasing appearance. So, we need to find a material which can blend easily with bone and a technique to reduce scar formation. Unsintered hydroxyapatite (u-HA) particles and poly-Llactic (PLLA) composites (OSTEOTRANS MX®; Takiron Co., Ltd., Japan) are new-generation absorbable devices. They are bioactive and totally resorbable osteosynthetic bone fixation devices consisting of a composite material with bioactive, bioresorbable u-HA and carbonated ion containing fine particles combined with PLLA.[13] Some authors have reported that u-HA/PLLA composite may be appropriate for total replacement with bone.[14] To minimize scar formation, two-point fixations involving the infraorbital rim and the zygomaticomaxillary buttress for zygomatic fractures via the transconjunctival and gingivobuccal incisions can be performed.

AIM OF THE STUDY

The purpose of our study was to assess the stability as well as aesthetic outcomes of one-point fixation using a three-dimensional photogrammetric analysis.

METHODOLOGY

10 patients who underwent open reduction and rigid fixation for ZMC fractures using u-HA/PLLA composites and who could be observed and followed for longer than 6 months were enrolled in this study. The inclusion criteria were type III, IV, and V ZMC fractures according to the Knight and North classification. Patients who had bilateral ZMC fractures, comminuted ZMC fractures, a previous history of craniofacial surgery, or a history of congenital facial asymmetry were excluded from this study. The study conformed to the Declaration of Helsinki, and written consent was obtained from each patient for both the surgery. A gingivobuccal incision was made 1 cm above the attached gingiva and then deepened through the buccinator straight to the anterior maxillary wall until the periosteum was identified. After the mucoperiosteal flap was elevated, fracture sites were identified. A Digman zygoma arch elevator could also have been placed accurately and applied to reduce bone fragments and correct the anatomical position. We performed one-point fixation at the ZM buttress region using u-HA/PLLA composites. The buttress region was fixed with a four-holed L-type plate (1.4mm thickness, 4.5mm width, 22 × 10 mm) and 8mm screws. After rigidity of the fixation was confirmed, the wound was copiously irrigated. Hemostasis was achieved, and watertight closure was obtained. Differences in the soft-tissue malar height between the fractured and unfractured sides were evaluated with photogrammetric analysis using the three-dimensional (3D) camera (Morphius®, Morpheus3D Co., Ltd., Korea). For measurement of soft-tissue inter-malar height, we used an arbitrary reference line parallel to the intercanthal line. The postoperative soft-tissue inter-malar height assessment was conducted with a 3D camera 1 week, 1 month, and 3 months after surgery. At 6 months after the operation, bony inter-malar height was evaluated using 3D CT. During the follow-up period after surgery, all patients underwent clinical and radiological assessment by independent observers. Statistical analyses were performed using SPSS software. The paired t-test was used to compare differences in malar height, and p-values $< .05$ were considered significant.

RESULTS

A total of 8 patients had an isolated ZMC fracture, and 2 had combined other facial bone fractures, such as orbital wall and nasal bone fractures. The mean follow-up period was 6 months. During the hospitalization and follow-up periods, there were no major complications, such as wound infection, plate exposure or fracture, bony non-union, or infection-related foreign body reaction. All 10 patients achieved satisfactory symmetric soft tissue malar appearance 3 months after surgery and bony stability and symmetric bony malar appearance 6 months after surgery.

Table 1- Differences between soft tissue malar height and bony malar height, between fractured and unfractured sides.

	Pre-operative	1 week	1 month	3 months	6months
Differences in soft-tissue malar height between the fractured and unfractured sides	− 6.38 ± 1.74mm	1.43 ± 1.48mm	− 1.41 ± 0.28 mm	− 1.39 ± 0.38mm	
Differences in bony malar height	− 5.34 ± 1.25mm				0.17 ± 0.03mm

The average postoperative difference in soft-tissue inter-malar height between the fractured and unfractured sides was − 6.38 ± 1.74mm (means ± standard deviation): it was 1.43 ± 1.48mm at 1 week, − 1.41 ± 0.28 mm at 1 month, and − 1.39 ± 0.38mm at 3 months. The difference in the soft-tissue inter-malar heights before and 1 week after surgery was statistically significant ($p < .01$). There was no statistically significant difference between these values at 1 and 3 months after surgery. The differences in bony inter-malar height were − 5.34 ± 1.25mm before and 0.17 ± 0.03mm 6months after surgery, which reflect a significant difference ($p < .01$) (Table 1)

DISCUSSION

Zygomatic fractures have traditionally been treated using 3-point fixations involving the zygomaticomaxillary buttress, infraorbital rim, and zygomaticofrontal suture.[5] Rohner et al. cadaveric heads. The experiments were performed on bare skulls, after making deliberate fractures and artificially inducing the expected downward acting masseteric muscle forces. However, Dal Santo et al.[6] reported that the actual masseteric muscle force that pulls down the zygoma is substantially reduced for 4 weeks after the trauma. Furthermore, Tarabichi[15] indicated that the zygoma is covered with soft tissue, such as the superficial musculo-aponeurotic system, which naturally acts as a resistant force against the masseteric downward forces. Attempts have been made to avoid transcutaneous incisions for zygomaticofrontal sutures, such as upper eyelid transconjunctival incisions; however, these approaches have not been generally accepted.[16] Certain surgeons state that the zygomaticofrontal suture is the least important point for determining the degree of rotation of the fracture, and the visualization with this approach is also not very helpful for achieving accurate reduction.[10] In the traditional three-point ORIF, ZF, IO, and ZM have been essential points for achieving stability in a ZMC fracture[5] and have been approached through lateral brow, subciliary or transconjunctival, and intraoral incisions, respectively. However, approaches via three points require a long surgery time and may result in complications including ectropion and noticeable scars. Although selection of ORIF with fewer than three points has been studied, most techniques include the ZF suture.[17] An important advantage of photogrammetry over direct anthropometry involves the ease of assessment (photographs are easier to analyze than evaluation of the patients face); however, its disadvantage is the fact that it is an indirect type of anthropometry. However, obtaining standardized photographs and comparing the ratios enables the evaluation of changes and differences between the fractured and contralateral sides before and after the operations.[18] Even small aesthetic changes in the periorbital region can result in changes in the facial expression and impression. Based on this finding, it was suggested that periorbital anthropometry, which detects small changes, could serve as a better method for evaluating zygomatic fractures than the measurement of bony changes.

Comparisons of the soft-tissue inter-malar height of the fractured and unfractured sides revealed statistically significant differences between before surgery and 1 week and 1 month after surgery. The difference in soft tissue inter-malar height 1 week and 1 month after surgery may have been caused not only by the minor decrease in bony malar height due to the masseter muscle action but also by the reduction in postoperative soft-tissue swelling. However, there was no statistically significant difference between 1 and 3 months after surgery. It means that the change of soft tissue inter-malar height mainly occurs within 1 month after surgery.

CONCLUSION

One-point fixation of a ZM buttress using u-HA/PLLA composites provides reliable, satisfactory, and safe clinical results in patients with ZMC fractures with mild and moderate displacement.

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