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Research Paper

Orbital Volume: An Enhanced Diagnostic Tool For Treatment Planning In Orbital Trauma.

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ABSTRACT: *Present day scenario sets considerable importance for visual acuity . The impact of any vision changes has a traumatic effect on the mind of the beholder. Various surgeons have multiple opinions regarding operating the orbital fractures. Orbital volume acts as an diagnostic tool for the orbital fractures treatment because for every 2cc increase in orbital volume there is an 1mm3 of enopthalmos , where surgical exploration of orbital floor (3)and its reconstruction helps in restoring volume and 1cc of alteration in orbital volume requires fixation of orbital rim. Hence , it aids in treatment planning as there are many controversies over operation orbital region.*

Key words: *orbit, orbital volume , CT , enopthalmos , diplopia.*

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I. INTRODUCTION

Orbital fractures are the commonly encountered fractures accounting for about 63 % of facial fractures among which medial wall and orbital floor fractures are the commonest. They can occur alone or in combination with the orbito-zygomatico complex, lefort , panfacial fractures(2). They are accentuated with muscular entrapment, incarnation , diplopia, infraorbital nerve paraesthesia, enophthalamos, blindness and also alter the bony architecture of the orbit thus altering the orbital volume.Thorough ocular examination to be done ,to check vision and pupillary response for optic neuropathy and to assess extraocular motility and forced duction for extraocular muscle entrapment, ischema, hemorrhage, or orbital compartment syndrome

Accurate measurement of orbital volume is essential for determining the extent of injury & planning surgical intervention.

Traditional indications for open reduction of orbital fractures are the presence of symptoms and signs such as diplopia, limitation of extraocular muscle motion, radiologic evidence of extensive fracture , and enophthalmos produced by an orbital volume (OV) change.

Computed tomography (CT) with multi-planar reconstruction is the reference imaging procedure for the assessment of cranio-facial injuries because it provides the best spatial resolution and analysis of osseous structures. It has been used as an standardised technique for the measurement of orbital volume(5).

This article explores the significance of orbital volume , its methods of assessment and its implications in the surgical management.

II. MATERIALS AND METHODS

We have reviewed a series of 10 patients reported with facial fractures involving orbit over a time period of may 2023 to march 2024 reported to department of oral&maxillofacial surgery, Mamata dental college and hospital , Khammam. In all the patients Three-dimensional CT images were taken pre operatively and post operatively.

The study's measurement methodology, combining planimetry and digital analysis through SYNGO software, provided consistent and reliable volume calculations. Axial and coronal CT sections with slice thicknesses of 5mm and 3mm respectively allowed for precise volume determination. The complementary use of both manual tracing and digital software analysis enhanced the accuracy of measurements, with high correlation between the two methods.

PLANIMETRY

Ct sectional images were taken in axial and coronal sections pre and post operatively .

The ct axial sections were traced manually and reconstructed as a cone , and volume calculated using HERON'S FORMULAE

Area = $\sqrt{s(s - a)(s - b)(s - c)}$.

The coronal sections were traced manually and reconstructed as a sphere and the volume is calculated by $\pi r2h$.

The orbital boundaries (superior, inferior, medial and lateral) were defined by the bony structures of the orbit; in case of bony interruptions or thin bony walls, a straight line was drawn between the nearest bony boundaries. [1] (4)

DIGITAL ANALYSIS

The axial and coronal sections volume are calculated using syngo software(9).

Facial CT scans and OVR measurements

The OV was computed by summing the volumes between the two scan sections, which was calculated by averaging the area of 2 adjacent scan sections and multiplying by section thickness: Volume = Σ $(slice_n+slice_{n+1})/2 \times$ thickness .[1]

Orbital volume ratio (%) =

Orbital volume of traumatised side / Orbital volume of normal side X 100.

INCLUSION CRITERIA

1. Orbital Fractures involving zygomatic complex.
2. Lefort fractures involving orbit.
3. Pan facial fractures involving orbit.

EXCLUSION CRITERIA

1. Blindness
2. Unwillingness for surgery
3. Medical fitness

III. Results

The study analyzed orbital volume measurements in 10 patients with facial fractures involving the orbit, comprising 7 males (70%) and 3 females (30%). The age distribution showed a predominance of young adults, with 60% of patients in the 25-35 year age group, 30% in the 15-25 year group, and 10% in the 35-45 year group. The most common fracture pattern observed was the combination of zygomaticomaxillary complex, orbital floor, and frontozygomatic (ZB+OF+FZ) fractures, accounting for 40% of cases.

Preoperative orbital volume measurements revealed significant variations from the normal contralateral side. The mean preoperative orbital volume was 30.53 ±1.12 cc, compared to a mean normal side volume of 29.01 ±0.42 cc. This disparity resulted in a mean preoperative orbital volume ratio of 106.8% (range: 102.5-112.3%), indicating consistent orbital enlargement across all cases. The largest preoperative volume discrepancy was observed in patients with combined ZB+OF+FZ fractures, suggesting a correlation between fracture complexity and orbital volume disruption.

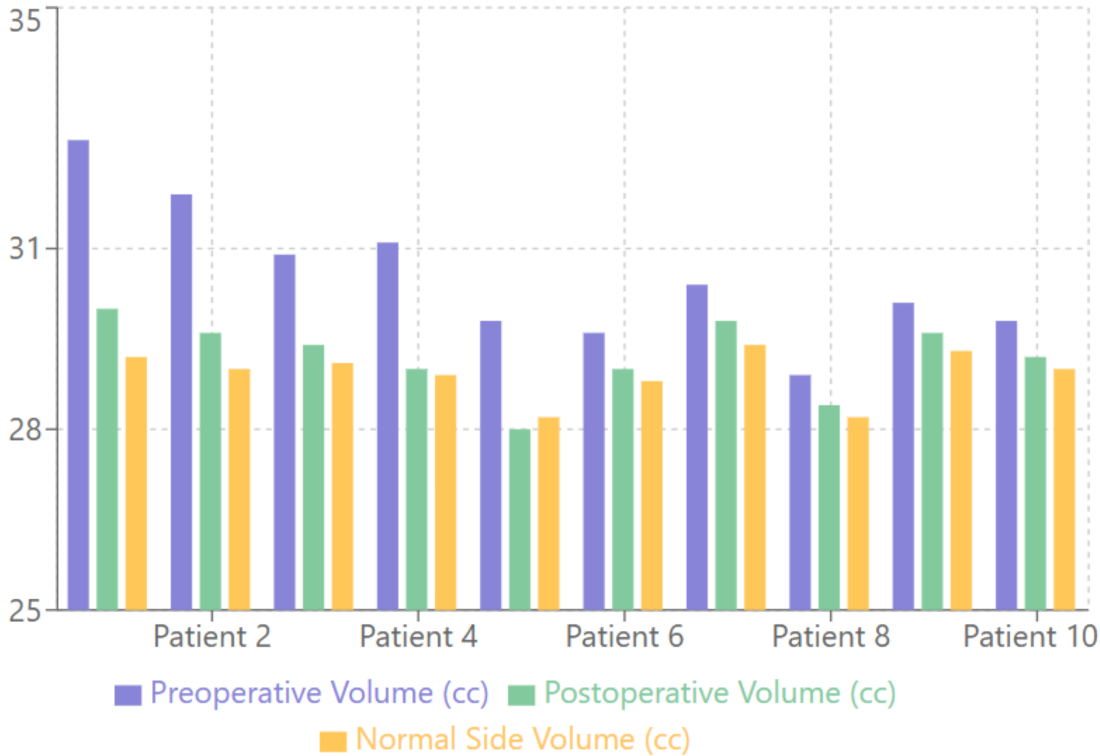
Postoperative measurements demonstrated significant improvement in orbital symmetry. The mean postoperative orbital volume decreased to 29.20 ± 0.61 cc, resulting in a mean postoperative orbital volume ratio of 101.4% (range: 99.3-102.7%). This represents a mean volume reduction of 1.33 cc and an average improvement in orbital volume ratio of 5.4%. Notably, the standard deviation of orbital volume ratios decreased from 3.4% preoperatively to 0.9% postoperatively, indicating more consistent and symmetric orbital volumes following surgical intervention.

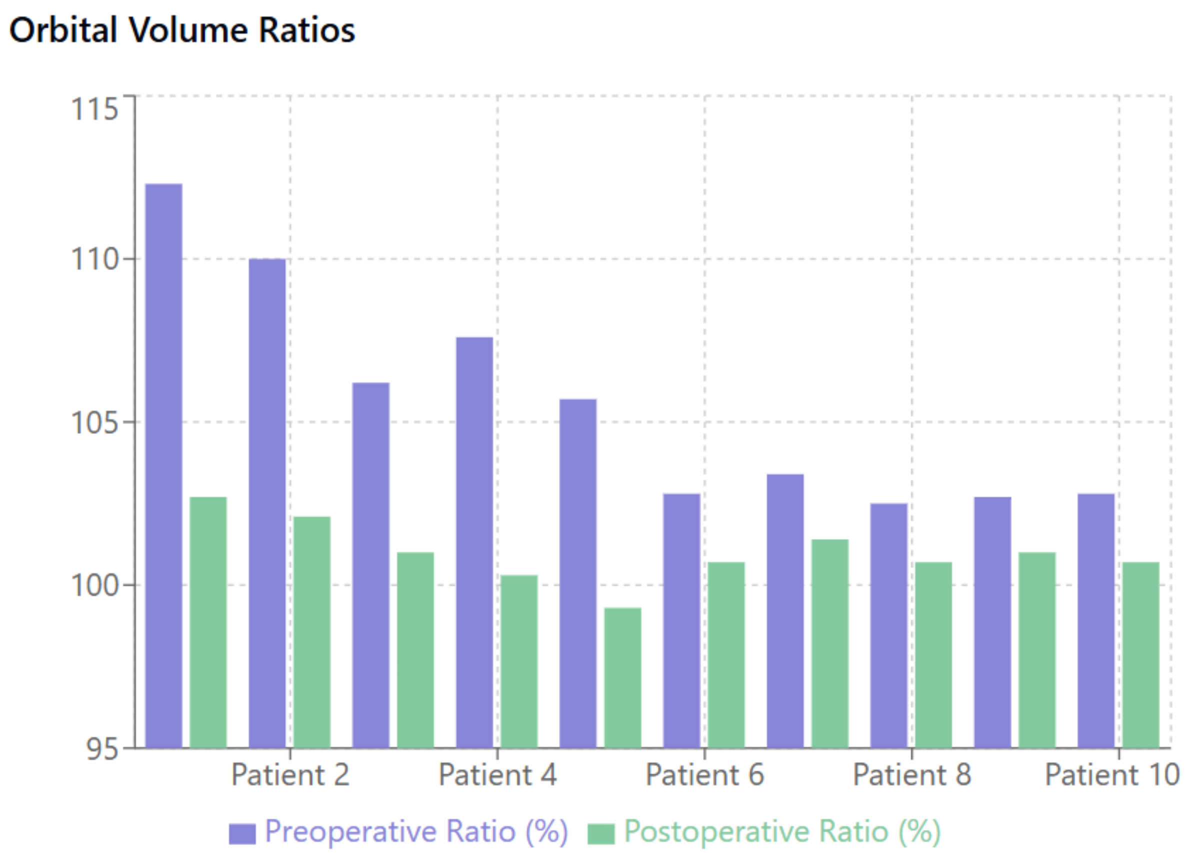
Statistical analysis using paired t-tests confirmed the significance of these improvements ($p < 0.001$). All patients achieved postoperative volume ratios within 3% of the ideal 100% ratio, suggesting successful restoration of orbital symmetry. The most substantial improvements were observed in cases with preoperative ratios exceeding 110%, where careful volume reduction near symmetry with reducing postoperative ocular disturbances . These results demonstrate that orbital volume analysis serves as a valuable quantitative tool for both surgical planning and outcome assessment in orbital fracture repair. The achievement of postoperative volume ratios approaching 100% across all cases, regardless of initial fracture pattern or severity, underscores the utility of orbital volume measurements in guiding surgical reconstruction and achieving optimal orbital symmetry.

Table 2: Statistical Summary

Metric	Preop Volume (cc)	Postop Volume (cc)	Preop Ratio (%)	Postop Ratio (%)
Mean	30.53	29.20	106.8	101.4
Median	30.25	29.30	105.7	101.0
Standard Deviation	1.12	0.61	3.4	0.9
Minimum	28.90	28.00	102.5	99.3
Maximum	32.80	30.00	112.3	102.7
Volume Reduction (Mean)	1.33	-	-	-
Ratio Improvement (Mean)	-	-	5.4	-

Orbital Volumes Comparison





IV. DISCUSSION:

The management of orbital facial fractures has been debated for many years, and the literature contains conflicting approaches to the appropriate care for these patients. This confusion in approach has had both medical and medico-legal implications. The "ideal" time to intervene after fracture occurrence remains elusive(10). The definitive treatment of the orbital fractures depends on several factors restrictive ocular motility , enopthalamos, severity of fractures , surgeons choice .Indications and timings of surgery of orbital floor fractures is controversial..

According to Deutschberger & krishner , the cardinal factor determining the necessity of surgical intervention is size of defect. Defects less than 0.5cm do not require surgical intervention while those between 0.5-1.0 cm require surgical intervention only if signs and symptoms are evident, where as all defects greater than 1cm require surgical intervention. Designating the extent of enophthalmos that is noticeable re- mains controversial, but many studies have agreed that 2 mm of relative enophthalmos should be considered cosmetically sig- nificant . For every 2cc increase in orbital volume there is an 1mm3 of enopthalamos.

Enopthalomos has been seen more in the orbital floor fracture compared to the lateral wall, medial wall and roof of orbit . The reasons may include reduced bony support , gravity . Henceforth , due to an increased chances of enophthalmos in orbital floor fractures , they need to undergo surgical intervention.

This study has some limitations. We haven't equally distributed the fracture cases regarding the fracture pattern and medial wall fractures has not been operated.

There are many considerations for selecting the treatment plan for orbital fractures in which measuring the orbital volume plays a pivotal role , it helps in assessing the treatment plan to operate the orbital region due to the various complications and controversies associated.

Along with the treatment plan , selecting the various surgical approaches for the infraorbital rim also remains controversial. There are various approaches like subciliary , sub tarsal , infraorbital rim , transconjuctival incisions . All of them having its own limitations , where subciliary , subtarsal incisions have the risk of scarring and entropion whereas , transconjuctival incision will provide an limited exposure to the area.

There are many criteria that comes for selection of treatment plan in which orbital volume plays an pivotal role.

Restoring orbital volume is important because it causes a significant alteration in visual acuity of the patient postoperatively. The normal orbital volume of the patient is 25-30mm3. In our study we found out that fixation of zygomatic maxillary buttress also significantly improves the orbital volume of the patient to about 0.5cc whereas is an alteration of greater than 0.5 - 1 cc in fixation of infraorbital rim and frontozygomatic suture , significant alteration of greater than 2 cc in fixation of orbital floor reconstruction.

Hence , according to the difference in the orbital volume , the treatment plan can be made to ensure a proper visual acuity , and decreased visual disturbances postoperatively to the patient.

V. Conclusion

To conclude, orbital volume acts as a key factor in treatment planning as it guides us in restoring the visual acuity and helps us for an enhanced postoperative ocular health by restoring post operative ocular movements and also an normal intraocular pressure.

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Conflicts of interest

There are no conflicts of interest

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