Computer Aided Volume Measurement Using Osirix, A Free 3D-Rendering Software, In Preplanned Correction Of Enophthalmos With Diced Cartilage Graft

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Background: Autologous costal diced cartilage graft is an option for replenishment of the volume deficit in residual enophthalmos following orbito-zygomatic trauma. However, in published journals referring this treatment option, quantitative volume measurement of the graft needed has not been established.
Methods: Two patients with orbito-zygomatic fractures resulted from motorcycle accidents, presented with dystopia, entrapment of the eyeball, diplopia, and depressed malar eminence on the affected side. CT scans demonstrated orbital-floor disruption and herniation of the intra-orbital content into the maxillary sinus. Using OsiriX®, a free and open source medical imaging software, we calculated the volume discrepancy of the affected orbit. On coronal slices, the segmentation of the bony orbital region of interest of each single slice was performed and grouped to compute the volume. At surgery, diced cartilage grafts were inserted to the orbital cavity according to the calculated volume, to promote forwards shift of the eye globe position after releasing the entrapment and replacing the orbital floor.
Result: In both patients, good position of the eye globe was achieved. The aesthetic appearance was perceived as quite acceptable to the patients and other viewers. Transient diplopia settled within 3 months.
Conclusion: We considered OsiriX® as a reliable tool for accurate quantitative measurement of diced cartilage graft volume in enophthalmos correction.
Keywords: *OsiriX®, computer-aided volume measurement, diced cartilage graft, enophthalmos correction.*

Latar Belakang: *Autogolous costal diced cartilage graft* merupakan salah satu pilihan untuk mngatasi defisit volume di enophthalmos residual yang diakibatkan orbito-zygomatic trauma. Bagaimanpun, pengukuran quantitatif dari volume graft yang diperlukan belum diteliti di jurnal internasional.
Metodologi: Dua pasien dengan fraktur orbito-zygomatic karena kecelakaan motor, datang dengan kelainan dystopia, *eyeball entrapment,* diplopia dan depresi regio malar.enggunakan Osirix, sebuah software gratis dan bebas sumber, kami menghitung perbedaan volume yang diperlukan dari orbital tersebut. Pada saat operasi cartilage graft yang telah dicacah dimasukkan ke ringga orbita sesuai dengan volume yang diperlukan, untuk memperbaiki kerusakan dan mengembalikan fungsional gerak bola mata.
Hasil: Pada kedua pasien, posisi bola mata yang baik telah dicapai. Penampilan estetik pun telah didapat kesan baik. Diplopia transien pun diperoleh setelah 3 bulan
Kesimpulan: Kami berkesimpulan bahwa Osirix adalh sebuah alat yang akurat sebagai pengukuran quantitatif untuk mengukur kebutuhan volume dari *diced cartilage.*
Kata Kunci: *OsiriX®, computer-aided volume measurement, diced cartilage graft, enophthalmos correction*

The principal theories of the mechanism of posttraumatic enophthalmos are enlargement of the bony orbit, loss of ligament support and posttraumatic fat atrophy, scar contracture, and neurogenic. Manson et al evaluates these theories by means of CT scanning techniques and analysis. The study revealed an increased soft tissue orbital volume of 5% and increased bony orbital volume of up to 18%.[1] While Bite et al found an absolute reduction of tissue content resulting from fat loss or cicatrical contraction.[2] Consequently, the fundamental treatment modalities include bony alignment restoration and volume replenishment with grafting materials.3 For fracture involving the orbital floor, the integrity of the floor should be restored with a sturdy wafer, thereby correcting

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both the enophthalmos and hypophthalmos at the same time.[4]

Autogenous cartilage graft has several merits when used as a filler material. It is easy to harvest, relatively malleable, easy to reshape and resistant to resorption. Its role in ear reconstruction has been well established, and its application in enophthalmos reconstruction had also been documented.[4] Ortiz Monasterio was among the earliest surgeons to use cartilage for this purpose but did not give any detail about how to decide the proper amount of graft for each case.[5]

Lee proposed a guideline to predict the graft volume needed based on his clinical experience, which showed that the addition of 1.37–1.5 ml of graft material corresponded to 1 mm correction of enophthalmos. He recognized that individual variance exists, and that this guideline is applicable only to patients with enophthalmos of less than 5 mm.[4]

We tried to have a more precise calculation of the graft needed by using CT scan data, which will be processed with OsiriX®, to compute the orbital volume and thus the volume of the graft needed.

PATIENTS AND METHODS

In this paper, we will present 2 cases of orbito-zygomatic fractures with enophthalmos which will be corrected using costal diced cartilage grafts. Before the surgery, we calculated the volume of the cartilage grafts needed by processing the CT scan data (Digital Imaging and Communications in Medicine data) with OsiriX®, which is a free 3D rendering software available for download from http://www.osirix-viewer.com/Downloads.html.

The volumetric limits of the orbit were defined. The anterior boundary was defined by the posterior lacrimal crest (Fig. 1A.), and the posterior boundary was defined by the anterior part of the optic canal (Fig. 1B.). All measurements were performed through contiguous coronal section. The closed polygon function was selected to start the segmentation of the bony orbital region of interest of each single slice using a specific cursor (Fig. 2A, B.). At the end of the segmentation process, all the regions of interest were grouped and the volume was computed (Fig 3A, B and Fig. 4.)[6].

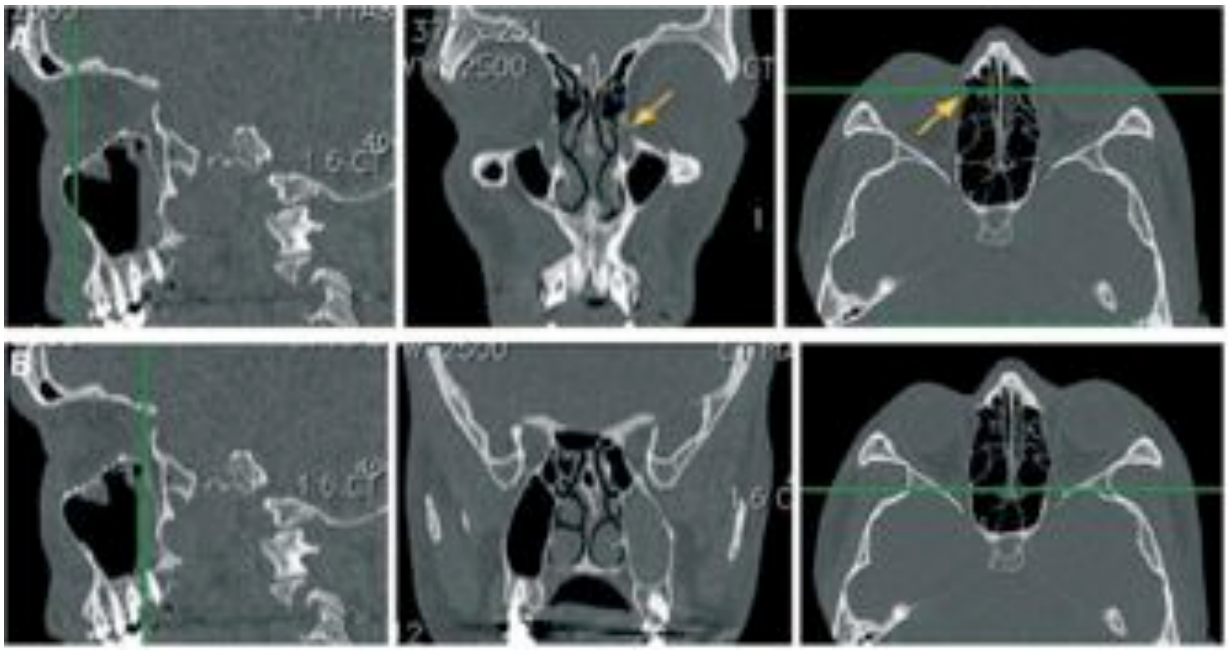

Figure 1. Sagittal, coronal, and axial CT images showing the volumetric limits of the orbit. (A) Anterior boundary defined by the posterior lacrimal crest (yellow arrow). (B) Posterior boundary defined by the anterior part of the optic canal.

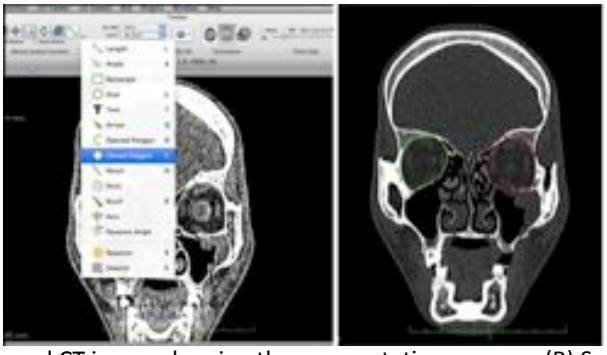

Figure 2. (A) Coronal CT image showing the segmentation process. (B) Selection of the closed polygon function to contour the bony orbital region of interest using a specific cursor.

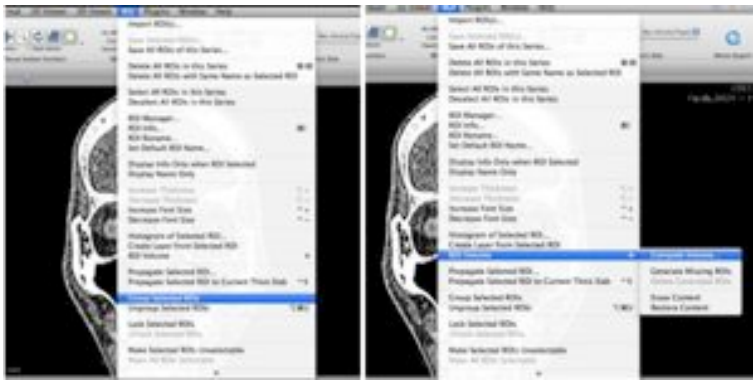

Figure 3. (A) Coronal CT image showing the grouping of all the regions of interest at the end of the segmentation process by using the Group Selected ROI function. (B) Coronal CT image showing the volume computation process by using Compute Volume of the Selected ROI function.

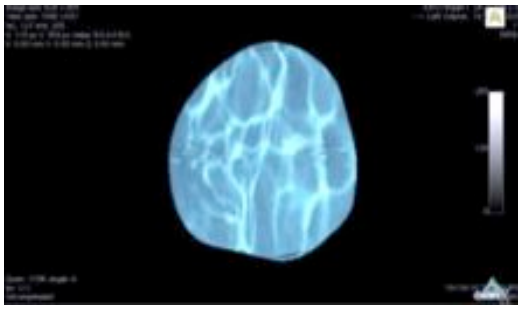

Figure 4. The Orbital Volume

Figure 5. Intraoperative view. (A) Diced cartilage grafts prepared in 1cc syringe for easier introduction to the orbit. (B) Diced cartilage grafts placed in the orbital floor above the orbital floor replacer (i.e. titanium mesh or piece of cartilage).

Case 1

A 23 year-old female presented to the outpatient department, she sustained an orbito-zygomatic fracture of the right side during a motorcycle accident 2 months prior to consultation. Physical examination revealed right-sided enophthalmos with dystopia, diplopia and entrapment of the eyeball to the upward gaze. A CT scan demonstrated orbital-floor disruption and herniation of the intra-orbital content into the maxillary sinus. Using OsiriX®, we calculated the volume of diced cartilage grafts needed with the method described above. In this case, the procedure was performed on the injured orbit. We made segmentation of the area below the level of the

orbital floor of the uninjured orbit. We computed the volume and the result was 3.3cc. At surgery, 3cc of diced cartilage graft were inserted to the orbital cavity to promote forwards shift of the eye globe position after releasing the entrapment and replacing the orbital floor with orbital mesh. A good position of the eye globe was achieved. The aesthetic appearance was perceived as quite acceptable to the patient and other viewers. The result remained stable during the 8-month of follow-up. Transient diplopia settled within 3 months.

left malar bone. There was herniation of the intra-orbital content into the maxillary sinus. We calculated the volume of diced cartilage grafts needed using OsiriX® with the method described above. In this case, the procedure was performed on both orbits, and the volume of the grafts needed is the volume of the injured orbit minus the volume of the contralateral uninjured orbit. We computed the volume of the left orbit which was 16.7cc, we also computed the volume of the right orbit which was 14.8cc, and the volume of the grafts needed was the

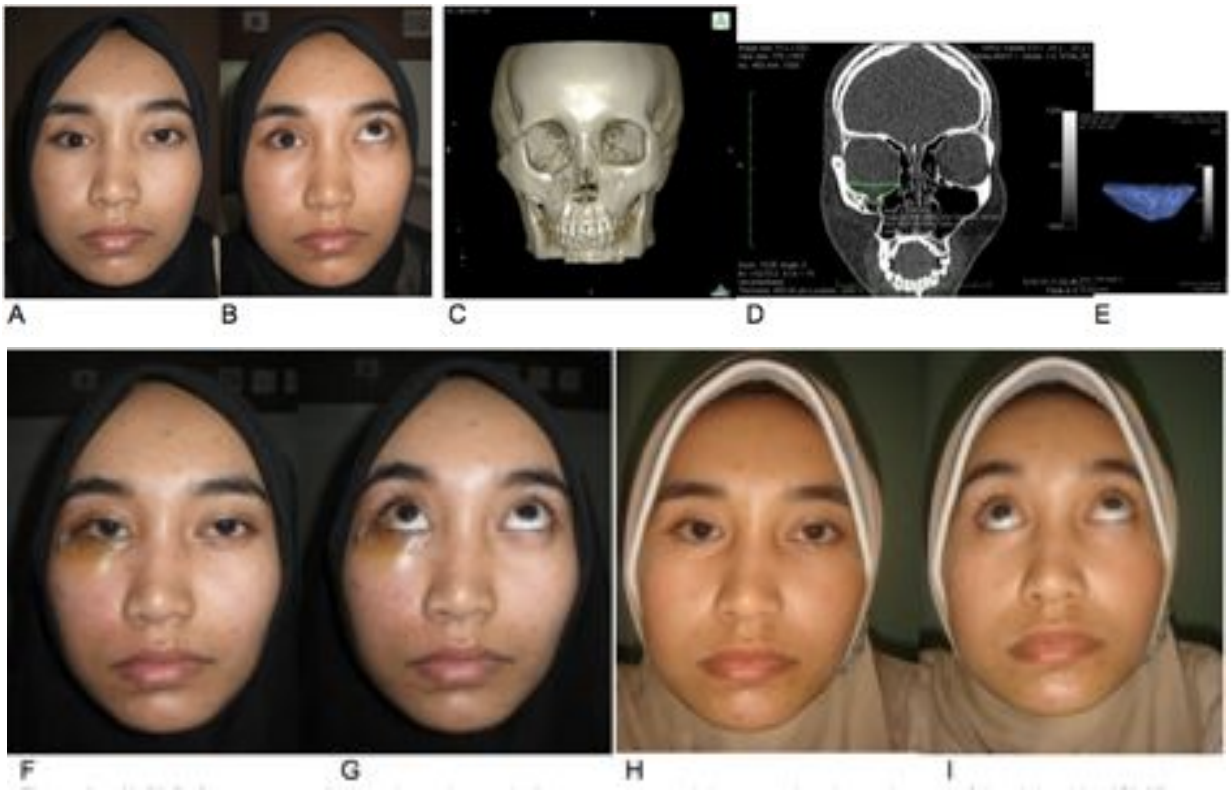

Figure 6 – (A-B) Before surgery, distinct dystopia, eyeball entrapment, and depressed malar eminence of the right side. (C) 3D CT before surgery. (D) Coronal view with segmentation of the area below the level of the orbital floor of the uninjured orbit. (E) Computed volume (3.3cc). (F-G) 4 days after surgery. (H-I) 8 month-follow-up.

Case 2

A 20-year-old male motorcyclist suffered an orbito-zygomatic fracture of the left side. He presented to the emergency room with left sided enophthalmos, dystopia, diplopia and entrapment of the eyeball to the upward gaze. The CT scan revealed orbital floor fracture, the medial fragment was depressed inferiorly. There was also posterior displacement of the

subtractions of the orbits which was 1.9cc. At surgery, we performed release of entrapment and we put a piece of costal cartilage graft over the depressed orbital floor. Afterward, 2cc of diced cartilage graft were inserted to the orbital floor. We also inserted 1 cc of diced cartilage graft on top of the posteriorly displaced left malar bone. Forward shift was achieved and the result remained stable during the 3-month of

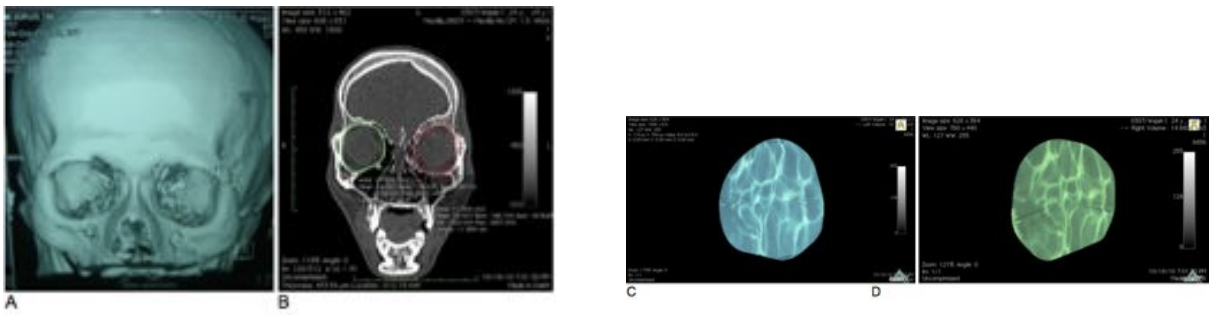

Figure 7. (A) 3D CT scan before surgery. (B) Coronal view which will be segmented. (C) Computed volume of the left orbit. (D) Computed volume of the right orbit.

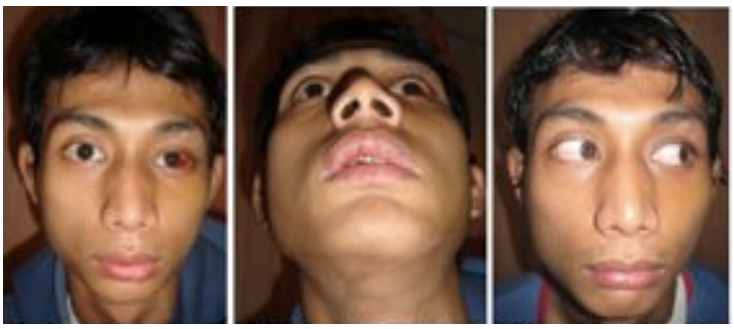

Figure 8. Before surgery, distinct dystopia and inferoposterior shift of the eye globe. Posteriorly displaced malar bone. Diplopia on upward and lateral gaze with slight eyeball entrapment.

Figure 9. Four days after surgery, eye globe position is relatively symmetrical. Slight overcorrection of the depressed left malar bone. Entrapment is release.

Figure 10. Six months after surgery, eye globe position is level. Malar bones are level. No entrapment, no diplopia.

follow-up. Transient diplopia settled within 3 months.

DISCUSSION

Both of our patients suffered disfiguring enophthalmos after high velocity orbitozygomatic trauma. High-velocity impact results in bony-structural distortion in which the reparative task becomes much more complicated. In addition to the practical difficulties in achieving exact anatomical bony reduction, there exists another confounding factor of actual soft-tissue decrement. Although bony- volume expansion has been widely accepted as a major etiological cause for enophthalmos, it is by no means the only relevant parameter. A multitude of studies have illustrated that soft-tissue reduction does play a role.[2,7] Post-traumatic fibrosis of the periocular adipose tissue is likely to occur, which will condense the fat component into a more compact and stiffer tissue block. Besides that, the intra-orbital content that herniates into the adjacent sinuses may undergo ischemic necrosis due to strangulation of the nutrient vessel.8 In all these situations; a shrinkage in the soft-tissue bulk is apparently expectable, which in turn would provoke late enophthalmos. In light of this, volume manipulation should be considered an integral part of the treatment strategy.[3]

In both of our patients, we achieved bony alignment and performed internal fixation with plate and screw. Both of our patients had orbital floor disruption with herniation of the intra-orbital content into the maxillary sinus. We replaced the orbital floor with orbital mesh in the first patient, and in the second patient we replaced the orbital floor with a piece of costal cartilage. Afterward we restored the volume with diced costal cartilage graft.

Many studies have tried to find the best methods to make an accurate quantitative measurement of the orbits and also the volume replenishment respectively.[1-4, 6] In this report we applied what Scolozzi et al performed in their study to measure the orbit volume. Preoperatively, we used computer software to generate 3D volume from the CT scan data (OsiriX®) to make a quantitative measurement of the orbits and the volume of the grafts needed. During surgery we applied the volume of the grafts as calculated before.

By having a quantitative measurement of the grafts needed before surgery, we were able to plan the exact amount of the costal cartilage to be harvested. During surgery we managed to save time and effort in harvesting the costal cartilage limited to the volume as planned before.

At the earliest follow up after surgery, both patients complained persistent diplopia but clinically the position of the eye globes are level and the entrapment is released. The diplopia settled within 3 months. At the subsequent follow up the aesthetic appearance was improving and perceived as quite acceptable to the patients and other viewers.

CONCLUSION

From our 2 cases, transient diplopia settled within 3 months and there were no other major sequelae after the operation. The follow-up period ranged from 6 to 8 months. The improved appearance and the stable results confirm the validity of this method to calculate graft volume needed.

We considered OsiriX® as a reliable tool for accurate quantitative measurement of diced cartilage graft volume in enophthalmos correction.

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