Comparison of Efficacy of Mandible and Iliac Bone as Autogenous Bone Graft for Orbital Floor Reconstruction

Vipul Garg · Girish B. Giraddi · Swati Roy

Received: 6 July 2013 / Accepted: 23 June 2014 / Published online: 29 July 2014
© The Association of Oral and Maxillofacial Surgeons of India 2014

Abstract

Objective This study evaluated and compared the efficacy of mandible and iliac bone as autogenous bone graft for correction of orbital floor fractures.

Patients and Methods Twenty patients who suffered orbital floor fractures took part in the study. The subjects enrolled in the study sustained both isolated orbital floor fracture and orbital floor fracture associated with fracture of zygomatico-maxillary complex. Each inferior orbital wall was reconstructed using either a mandible bone graft or an iliac graft. Mandibular symphysis was opted as a donor site for graft harvest from mandible and anterior iliac crest for the iliac group. CT scans were taken before the operation. Inclusion criteria consisted of at least 2 months postsurgical follow-up, pre- and post-surgical photographic documentation, and complete medical records regarding inpatient and outpatient data. To describe the distribution of complications and facilitate statistical analysis, we categorized our findings into diplopia, enophthalmos, and restriction of ocular movements before and after treatment.

We also considered the time required for the harvest of the grafts and the donor site complications. A comparative study was carried out using Chi square test and student *t* test. We considered *P* value <0.05 to be statistically significant.

Results Ten iliac crest grafts and ten mandible bone grafts were placed. The mean age of the patients was 33.1 years. 80 % of the patients were males. The most common complication of orbital floor fracture was diplopia, followed by enophthalmos and restriction of ocular movements. The post operative results were compared after 2 months of the surgery. In iliac crest group, diplopia got corrected in six out of seven patients (85 %), enophthalmos in four out of five patients (80 %) and restricted ocular movement showed 100 % correction. While in mandible group, diplopia and ocular movement showed 100 % correction and enophthalmos got corrected in five out of six patients (83 %). No statistically significant differences were found between the two groups on comparing these variables. On the other hand the mean time required for the harvest of iliac graft and mandible graft was 30.2 ± 3.52 min and 16.8 ± 1.75 min respectively. The difference was statistically significant.

Conclusion There is no difference in the ability of mandible and anterior iliac crest bone grafts to correct post-traumatic diplopia, enophthalmos and restricted ocular movements. But the time and ease of harvest of the graft from mandible was comparatively less and easy especially when the treating doctor was an oral and maxillofacial surgeon. Secondly the post-operative morbidity was low and the quality and contour of the bone graft was very adaptable for the reconstruction of the orbital floor.

Keywords Orbital floor · Fracture · Reconstruction · Graft · Mandible · Iliac bone

V. Garg (✉)

Department of Oral and Maxillofacial Surgery, Himachal Institute of Dental Sciences (HIDS), Paonta Sahib, Himachal Pradesh, India
e-mail: vips.saggy@gmail.com

G. B. Giraddi

Department of Oral and Maxillofacial Surgery, Government Dental College and Research Institute, Bangalore Fort, Karnataka, India

S. Roy

Department of Oral and Maxillofacial Pathology, Himachal Institute of Dental Sciences (HIDS), Paonta Sahib, Himachal Pradesh, India

Introduction

The orbital floor is one of the most frequently damaged parts of the maxillofacial skeleton during facial trauma. Unfavourable aesthetics and functional outcomes are frequent when it is treated inadequately [1].

Indications for repair of orbital fractures include clinically evident enophthalmos, dystopia, diplopia of more than 2 weeks duration and a forced duction test that shows entrapment of tissues and/or CT evidence of displaced soft tissues. Successful correction of an orbital wall injury requires early diagnosis and treatment. If the injury is left untreated, there is a tendency for malunion and further changes in the position and integrity of the soft tissues [2]. The treatment consists of spanning the floor defect with a material that can provide structural support and restore the orbital volume. This material should also be biocompatible with the surrounding tissues and easily reshaped to fit the orbital floor. Although various autografts or synthetic materials have been used, there is still no consensus on the ideal reconstruction method of orbital floor defects [1].

Orbital floor defects have been repaired with several types of alloplastic, allergenic, and autogenous materials. Autogenous grafts are best tolerated by the surrounding tissues. However, they require a second surgical procedure to harvest, which may increase the morbidity. Orbital floor defects have been reconstructed with autogenous bone grafts from the calvarium, antral wall, ilium, rib and mandible. The choice of a particular source is dependent on several factors. These include surgical access, the size of the defect to be repaired, donor site morbidity, and the quality and quantity of available bone [3].

The anterior iliac crest is the most common donor site, providing autogenous bone with the highest concentration of osteocompetent cells [4]. However, the main advantage of using a local donor site is convenient surgical access. This translates into reduced operative and anaesthesia time in a single team effort. The harvesting procedure can be performed in the office or as an outpatient in the hospital. The decreased morbidity of local donor sites over distant sites and the use of a transoral approach, which does not result in a cutaneous scar, make this procedure more easily acceptable to the patient [5].

Through the present study, we aim to compare the success rate and result of mandible graft with that of iliac bone graft for the correction of orbital floor defects. The mandibular symphysis was selected as a donor site from mandible as this site is a readily available source of autogenous bone that can be harvested with minimal morbidity as compared to lingual plate of mandible and lateral aspect of ramus. Its contour is suitable for use in orbital floor reconstruction. Grafts measuring about 2 to 4 cm can be harvested from the symphysis. Grafts of this dimension would find application in the repair of the majority of orbital floor defects.

Patients and Methods

Twenty patients with isolated orbital floor fracture or orbital floor fracture associated with ZMC fractures and requiring reconstruction who reported to the Department of Oral and Maxillofacial Surgery were enrolled in this study (Fig. 1a). In subjects with orbital floor fractures associated with ZMC fractures, the ZMC was appropriately treated using open reduction and miniplate fixation. The research was approved by the local institutional review board and ethical clearance was given for the same. Additionally, informed signed consent was taken from the subjects. The included patients were randomly divided into two equal groups (10 patients in each group), one group receiving mandibular symphysis graft and the other receiving anterior iliac crest graft. Patients with any other systemic disease, less than 2 months surgical follow-up, incomplete medical records, no photographic documentation of the changes and with mandible, pelvic bone fractures were excluded from the study. Only those subjects were enrolled in the study in whom the required correction of orbital floor defect was less than 2 cm as this amount can be easily obtained from the selected donor sites.

The procedures to be performed were explained, followed by informed written consent. Clinical diagnoses and the size of the bony defect were confirmed by means of computed tomography (CT) imaging (Fig. 1b, c). The treatment for all the patients were scheduled after 1 week of reporting as the finding like enophthalmos is difficult to judge in presence of soft tissue swelling and edema. The senior oral and maxillofacial surgeon made the treatment decisions and performed the operations including those relating to the graft harvest from both mandibular symphysis and anterior iliac crest. The inferior orbital wall was explored via subciliary or transconjunctival approaches. Only after the orbital floor exploration, the bone graft was harvested from the respective donor sites. The type of graft that was harvested was cortico-cancellous in nature. The graft was appropriately trimmed, contoured and then placed in position and stabilized with the help of sutures or screws. The suture or screw holes were drilled through the graft and into stable bone of the orbital floor (Fig. 2a, c).

Follow-up was scheduled for 1, 4, and 8 weeks, and measurements were obtained and recorded for as long as patients participated in the follow-up program.

All patients received grafts to the inferior wall i.e. the orbital floor. The operative notes were evaluated for the time required in the harvest of the graft. The surgical sites were examined for evidence of infection, extrusion of the bone graft at the infraorbital rim, loss of contour of symphysis and mental nerve paresthesia. All the preoperative and post operative findings were recorded in a case history performa. To describe the distribution of complications and to facilitate

Fig. 1 **a** patient with fracture of orbital floor (right eye)—clinical photograph **b** CT IMAGE: coronal view **c** CT IMAGE: sagittal view

statistical analysis, we categorized our findings into diplopia, enophthalmos, gaze restrictions and donor site complications. With respect to statistical analysis, contingency tables were used for both graft groups (mandible bone graft and iliac crest bone graft) and a comparative study was carried out with the chi-square test. Student t test was used to

compare the time required for the procurement of the graft. We considered P value <0.05 to be statistically significant.

Results

Sex and Age Distribution

There were 16 males and 4 females, with a mean age of 33.1 years (range 19–43 years) (Table 1).

Cause of Injuries

The most common cause of fracture was motor vehicle accidents (12 cases, 60 %), followed by inter personal violence (Table 1).

Complication of the Fractures

Complications included diplopia in 14 cases, enophthalmos in 11 cases, and limitation of ocular movement in 8 cases (Tables 2, 3).

Mandible Bone Graft

Preoperatively, seven out of ten patients had diplopia and six patients had enophthalmos. At the last follow-up, diplopia resolved in all the patients (100 % correction) while enophthalmos was registered in one patient (83 % correction). Restrictions of the eye movements was present in four patients and at the end of the follow-up, no patients had clinically detectable restrictions (Table 3). Time required for the procurement of graft from mandibular bony structure (symphysis) was 16.8 ± 1.75 min (Fig. 3a–b). One of the patients showed donor site complication as mild paresthesia in the mental region. The healing at the donor site was excellent and there was no scar formation (Fig. 3c).

Iliac Crest Bone Graft

Preoperatively, seven out of ten patients had diplopia. At the last follow-up, diplopia was detected in only 1 (85 % correction) patient. Enophthalmos was registered preoperatively in five patients. At the last follow-up visit, 1 (80 % correction) patient presented with enophthalmos. Restriction of the eye movements was present in four patients and at the end of the follow-up, no patients had clinically detectable restrictions (Table 2). Time required for the procurement of graft from iliac crest was 30.2 ± 3.52 min (Fig. 4a–c). Two of the patients showed donor site complication as visible scar formation (Fig. 4d). No gait disturbance was found in any patient after the last follow up.

Table 1 Data on 20 patients who suffered orbital blow-out fracture

Mandibular (symphysis) graft				Anterior iliac crest graft		
Pt no.	Age/gender	Etiology	Delay in operation (days)	Age/gender	Etiology	Delay in operation (days)
1	40/F	Accident	07	35/M	Assault	08
2	38/M	Accident	10	28/F	Accident	12
3	28/M	Assault	05	30/M	Accident	14
4	35/M	Accident	06	36/M	Assault	07
5	30/M	Accident	14	32/M	Accident	05
6	32/M	Accident	10	30/F	Assault	07
7	19/M	Sport	05	38/M	Accident	08
8	28/F	Assault	12	40/M	Accident	10
9	32/M	Accident	07	38/M	Accident	12
10	30/M	Assault	08	43/M	Assault	14

Table 2 Detected preoperative/postoperative findings for the ten patients who suffered blow-out fracture-using iliac crest (anterior) graft

Patient number	Diplopia pre O/post O	Enophthalmos pre O/post O	Restriction in movement pre O/post O	Donor site complication
1	+/-	+/-	-/-	-
2	-/-	+/-	Dw/-	-
3	+/-	-/-	Up/-	-
4	+/-	+/-	-/-	-
5	-/-	-/-	-/-	-
6	+/-	-/-	Dw/-	-
7	+/+	+/+	-/-	+
8	+/-	-/-	Dw/-	+
9	+/-	+/-	-/-	-
10	-/-	-/-	-/-	-

+ present; - absent

Table 3 Detected preoperative/postoperative findings for the 10 patients who suffered blow-out fracture-using mandibular graft

Patient number	Diplopia pre O/post O	Enophthalmos pre O/post O	Restriction in movement pre O/post O	Donor site complication
1	+/-	-/-	Up/-	-
2	+/-	+/+	-/-	-
3	+/-	+/-	Dw/-	-
4	+/-	+/-	-/-	-
5	-/-	-/-	-/-	+
6	+/-	+/-	-/-	-
7	-/-	-/-	Up/-	-
8	+/-	+/-	-/-	-
9	+/-	+/-	-/-	-
10	-/-	-/-	Up/-	-

+ present; - absent

Fig. 2 a Harvest of the graft from symphysis of mandible b the graft; c good healing after harvest of mandibular bone graft

Table 4 Clinical finding before and after reconstruction

Symptom	Preoperative incidence		After surgery				<i>P</i> value
			Persistent		Resolved		
	Iliac Crest	Mandible	Iliac crest	Mandible	Iliac crest	Mandible	
Diplopia	7	7	1	0	6 (85)	7 (100)	0.49
Enophthalmos	5	6	1	1	4 (80)	5 (83)	0.42
Restriction in ocular movement	4	4	0	0	4 (100)	4 (100)	1.00
Donor site complications	–	–	–	–	2	1	>0.05

* Percentage correction within parentheses

Fig. 3 a–d Post operative photographs showing restoration of ocular movements

Comparative Analysis

In general, no significant differences were found among the two groups of patients for the various parameters analyzed except for the time required for the procurement of the graft. Post operative diplopia was found in 1 patient with iliac crest bone graft while in no patient with mandibular symphysis bone graft (P value >0.05), post operative enophthalmos was seen 1 patient of both the groups (P value >0.05). Restriction in ocular movement resolved in all the patients of both the groups (Table 4; Fig. 5).

Fig. 4 Harvest of graft from the iliac crest a skin incision; b osteotomy cut; c the graft; d visible scar formation secondary to harvest of iliac bone graft

Discussion

The orbital walls, being very thin, are easily damaged by rising intraorbital pressure, with subsequent diplopia as one of the most common problems (Figs. 4, 5). Entrapment or injury of the extraocular muscle, especially the inferior rectus muscle, damage of nerves, and change in the height of the eyeball caused by the reduction of intraorbital volume, are the most common causes of diplopia. Enophthalmos, another problem in blowout fracture, is attributed to several causes: loss of ligament and bone support for the globe and fat atrophy or fat loss [6]. Management of orbital fractures, whether pure blowout fractures or components of associated zygomatic bone fractures, is a challenging problem for the oral and maxillofacial surgeon. Their reconstruction requires (1) release of herniated orbital contents, (2) avoidance of enophthalmos, diplopia, and dystopia, (3) return of physiologic function of the extraocular muscles, and (4) an effective barrier against infection from the antrum [3].

Discussion is still ongoing for the choice of material for reconstruction and filling-in the defect of the orbital floor, especially that various autogenous and synthetic materials

Fig. 5 **a, b** The graft held in place with help of sutures

have been introduced for this reconstruction. Autogenous grafts have the advantages of biocompatibility and lower potential for infection, exposure, and foreign body reaction. Cortical bone and endochondral bones are widely used for reconstructing the orbital floor. Nevertheless, the drawback of bone grafts is unexpected resorption [6]. Kontio et al. [7] have reported almost 80 % resorption of iliac bone grafts, with 75 % concurrent new bone formation, probably because of the presence of osteoblasts in cortical bone. Regarding morbidity, complications at donor sites of autographic materials are few, most commonly scars and rarely cutaneous nerve injury. On the other hand, synthetic materials have demonstrated less donor site morbidity and facility in handling: polyethylene, hydroxyapatite, and silicon plates have been adapted for orbital floor reconstruction [8, 9]. However; these unabsorbable materials have higher potential for infection and foreign body reaction. Recently, progress in biomaterial science has provided another option: bioabsorbable materials that consist of mainly poly-L-lactic acid and polyglycolic acid, which are absorbed slowly and simultaneously replaced by tissues. Although these materials might be adequate for small defects of the orbital floor, they are not suitable for volume-demanding defects [1, 10–12].

In spite of substantial progress in the biomaterial science, autogenous bone remains the gold standard in maxillofacial reconstructive surgery. The goal in autogenous bone

harvesting is the acquisition of a specific quantity, quality, and contour of bone required for the reconstruction. If it is resorbable, it should be osteogenic, osteoconductive, or osteoinductive [13].

Many donor sites are available for obtaining small to moderate volumes of bone for maxillofacial reconstruction. These include the calvarium, iliac crest, tibia, ulna, mandibular symphysis, the rib, coronoid process, and so on. These harvest sites differ on the basis of their embryological characteristics (endochondral vs. intramembranous ossification), types of bone (cancellous vs. cortical), morphological and physical characteristics, the morbidity associated with harvest from the specific donor site, the volume of graft to be obtained, and the rate of their resorption. The desirable characteristics of a bone graft are sufficient volume, minimal donor-site morbidity, obtaining intramembranous bone with high cortical component, proximity to the recipient site, and ease of harvesting and achieving of reproducible and good results, and minimal resorption rate [2, 7, 13]. However, use of autogenous bone graft requires a second surgical site in an already traumatized patient [3].

Of the autogenous materials, mainly cortex bones such as cranial bone and iliac bone are used. Although the cortical bone is strong enough, processing it is not easy because of its strength and lack of flexibility to fit the contour of the orbital floor. Because the cortical bone contains a smaller number of cells such as osteoblasts and osteoprogenitor cells than do the periosteum and medulla bone, it provides poor remodelling and is sometimes absorbed [13]. On the other hand, it is also suggested that membranous bone grafts undergo significantly less resorption than endochondral bone grafts when applied to the craniofacial skeleton and that membranous bone grafts should be used preferentially. Enlow's work suggested that in case of orbit, most of the roof, medial wall, and floor are depository regions of bone growth; only a small portion of the superior and lateral rims is resorptive. The predominance of deposition sites might favour retention of bone grafts and may make the orbit a privileged site for grafting [2].

Kontio et al. stated that reconstruction of the orbital walls with iliac bone grafting is reliable. It restored the volume and shape of the orbit well. However as being a fairly rigid material, intraoperative three-dimensional assessment and accurate placement of the bone graft were difficult. The resorption rate was high, but most of the resorption was advantageous remodelling so a slight overcorrection is beneficial [7].

Siddique and Mathog compared cranial (membranous) versus iliac crest (endochondral) bone grafts as implants to correct post-traumatic globe malposition and/or diplopia and stated that there is no difference in the ability of cranial

and iliac crest bone grafts to correct post-traumatic enophthalmos [2].

Amrani et al. introduced an autogenous material with the merits of both autogenous and synthetic materials: the iliac cancellous bone which, although only 1 mm thick, is of sufficient strength because of its beamed structure. They also stated that it has the aspect of regenerative medicine, because the cancellous bone contains numerous hematopoietic stem cells and osteoprogenitor cells. They reported that no absorption has been observed at computed tomography follow-up; instead, ossification has been seen. They thereby suggested that iliac cancellous bone could take the place of other known materials and become a good choice for the reconstruction of the orbital floor [13]. In the present study we used cortical portion of the graft with little amount of cancellous bone attached to the inner surface to get the advantage of both as the cortical bone provides rigidity and the cancellous bone provides most of the osteoprogenitor cells.

However, use of cranial, iliac crest and rib graft resulted in several complications including conspicuous scars and pain associated with breathing or walking. Therefore, these bone-harvesting procedures were not readily performed especially in young women [14].

A variety of complications associated with iliac crest bone harvesting have been reported, including chronic pain, sensory loss, hematoma, seroma, wound breakdown, contour defect, hernia through the donor site, gait disturbance, instability of the sacroiliac joints, pathologic fracture, a dynamic ileus and urethral injury [4].

Kessler et al. reported that chronic donor site pain was present in 25 % of the patients after harvesting from the iliac crest. Pain at the donor site was reported in 34 % of the patients interviewed and was significantly higher than anticipated by the surgeons [15].

Kosaka et al. stated that the suitability of mandibular bone grafting for the treatment of orbital fracture has been documented. This approach affords numerous advantages in comparison with other donor sites. Since 1995, three distinct regions of the mandible namely mental region, area posterior to mental foramen and ramus region have served as donor site for bone grafts in the treatment of orbital blow-out fractures [14].

Krishnan and Johnson in 1997 have shown that the mandibular symphysis is an excellent source of bone for reconstruction of the orbital floor. They stated that it can be harvested with relative ease and low morbidity, and the quality and contour of the bone graft is very adaptable for the reconstruction of the orbital floor and such bone grafts can be used to repair defects measuring up to 2 cm in diameter [16].

Kosaka et al. listed out various advantages of using mandible as donor site for bone grafting: (1) Easy access to the donor site. As a result, operating time for harvesting is

greatly reduced and during harvesting, no “second team” is necessary. (2) Ease of trimming: The cortex is very thin; therefore, shaving of the appropriate thickness for the orbital floor is easy in comparison with iliac or calvarial bone. (3) Provides appropriate size and curvature for construction of the inferior and the medial floor. (4) Absence of functional disability (5) Lack of secondary deformity (6) No visible scar (This feature is the major advantage especially with young women). (7) Post-operative immobilization typically is not required. Patients wear facial bandages to prevent intraoral haematoma for several days post-operatively. (8) Absence of post-operative difficulty with respect to breathing and walking. (9) Major complications such as sensory disturbances were rare (4 % of cases); serious complications have never been observed. This is likely to the fact that important tissues or organs were absent in the surrounding layer, with the exception of the mental and infraorbital nerves [14]. However, several disadvantages associated with harvest from the mandible like (1) nerve damage, (2) infection, (3) quantity of harvest and (4) suture insufficiency has also been reported [14].

In the present study, we compared the efficacy of mandible and the iliac crest as a suitable graft material for the reconstruction of orbital floor. Findings showed that males were more at risk of orbital floor fractures, constituting 80 % of our cases. The mean age of the patients was 33.1 years. These data are similar to other findings from previous investigators like Al-Sukhun and Lindqvist [10] who reported a mean age of 37 years, while Krishnan and Johnson [16] and Wang et al. [17] reported a mean age of 28 years. Krishnan and Johnson [16] also reported a M:F ratio of 7:1. The reasons postulated were more men on the roads, including more night time driving, and their greater involvement in outdoor activities compared with women.

Our study also showed motor vehicle accidents were the most common mechanisms of orbital floor fractures (60 %) followed by the interpersonal violence. This finding does not differ much from the findings of other investigators [17, 18].

Social challenges, such as driving under the influence of drugs, alcohol intoxication, and perpetuating physical violence on the roads, have been increasing, transcending most cultural norms. The lack of law enforcement and road traffic regulation has contributed to the alarmingly increased rate of motor vehicle accidents [18].

In our study we observed that preoperatively the most common finding was in diplopia (70.0 %) followed by enophthalmos (55 %) and restriction in ocular movement (40 %). Similar results have been reported in previous studies.

Postoperatively diplopia got corrected in all patients (100 %) who received mandibular bone graft and in 85 % of patients who received iliac graft. Enophthalmos and

extraocular movement restriction also showed no statistically significant difference between the two groups (P value <0.05). The rate of success of orbital floor reconstruction has had many definitions according to the study design and methods used. In our study, we defined success on the basis of percentage correction of the pre operative complications.

However, considering the longer operative time (iliac crest = 30.2 min; mandible = 16.8) and potential morbidity to the iliac crest, mandible might be the better choice as an autogenous bone graft for the reconstruction of orbital floor reconstruction.

Conclusion

Our experience has shown no statistically significant difference between the two groups using iliac crest and mandible for the reconstruction of orbital floor on considering the postoperative parameters like diplopia, enophthalmos and restriction in ocular movement. However the time required for procurement of graft from iliac crest was significantly more than that required for mandible if done in a single team approach as in the present study. Secondly, the shape of the mandible surfaces exhibits various curvatures, i.e., curved area, protruded area, and broad, flat area. These variations may be applicable to the orbital walls which are themselves characterized by various curvatures. So, mandibular bony structure can be considered as an excellent source of bone for reconstruction of the orbital floor. It can be harvested with relative ease and low morbidity especially when the procedure is being performed by an oral and maxillofacial surgeon, and the quality and contour of the bone graft is very adaptable for the reconstruction of the orbital floor. So, the maxillofacial surgeon should, therefore, consider using this readily available source of bone when reconstructing the orbital floor defects measuring up to 2 cm in diameter.

References

1. Yavuzer R, Tuncer S, Basterzi Y, Isik I, Sari A, Latifoglu O (2004) Reconstruction of orbital floor fracture using solvent-preserved bone graft. *Plast Reconstr Surg* 113:34–44
2. Siddique SA, Mathog RH (2002) A comparison of parietal and iliac crest bone grafts for orbital reconstruction. *J Oral Maxillofac Surg* 60:44–50
3. Mintz SM, Ettinger A, Schmamel T, Gleason MJ (1998) Contralateral coronoid process bone grafts for orbital floor reconstruction: an anatomic and clinical study. *J Oral Maxillofac Surg* 56:1140–1144
4. Kalk WWI, Raghoobar GM, Jansma J, Boering G (1996) Morbidity from iliac crest bone harvesting. *J Oral Maxillofac Surg* 54:1424–1429
5. Montazem A, Valauri DV, St-Hilaire H, Buchbinder D (2000) The mandibular symphysis as a donor site in maxillofacial bone grafting: a quantitative anatomic study. *J Oral Maxillofac Surg* 58:1368–1371
6. Sakakibara S, Hashikawa K, Terashi H, Tahara S (2009) Reconstruction of the orbital floor with sheets of autogenous iliac cancellous bone. *J Oral Maxillofac Surg* 67:957–961
7. Kontio RK, Laine P, Salo A, Paukku P, Lindqvist C, Suuronen R (2006) Reconstruction of internal orbital wall fracture with iliac crest free bone graft: clinical, computed tomography, and magnetic resonance imaging follow-up study. *Plast Reconstr Surg* 118:1365–1374
8. Ng SG, Madill SA, Inkster CF et al (2001) Medpor porous polyethylene implants in orbital blowout fracture repair. *Eye* 15:578
9. Villarreal PM, Monje F, Morillo AJ et al (2002) Porous polyethylene implants in orbital floor reconstruction. *Plast Reconstr Surg* 109:877
10. Al-Sukhun J, Lindqvist C (2006) A comparative study of 2 implants used to repair inferior orbital wall bony defects: autogenous bone graft versus bioresorbable Poly-L/DL-Lactide [P(L/DL)LA 70/30] plate. *J Oral Maxillofac Surg* 64:1038–1048
11. Aitasalo K, Kinnunen I, Palmgren J et al (2001) Repair of orbital floor fractures with bioactive glass implants. *J Oral Maxillofac Surg* 59:1390
12. Rozema FR, Bos RR, Pennings AJ et al (1990) Poly(L-lactide) implants in repair of defects of the orbital floor: an animal study. *J Oral Maxillofac Surg* 48:1305
13. Amrani S, Anastassov GE, Montazem AH (2010) Mandibular ramus/coronoid process grafts in maxillofacial reconstructive surgery. *J Oral Maxillofac Surg* 68:641–646
14. Kosaka M, Matsuzawa Y, Mori H, Matsunaga K, Kamiishi H (2004) Orbital wall reconstruction with bone grafts from the outer cortex of the mandible. *J Craniomaxillofac Surg* 32:374–380
15. Kessler P, Thorwarth M, Bloch-Birkholz A, Nkenke E, Neukam FW (2005) Harvesting of bone from the iliac crest—comparison of the anterior and posterior sites. *Br J Oral Maxillofac Surg* 43:51–56
16. Krishnan V, Johnson JV (1997) Orbital floor reconstruction with autogenous mandibular symphyseal bone grafts. *J Oral Maxillofac Surg* 55:327–330
17. Wang S, Xiao J, Liu L, Lin Y, Li X, Tang W, Wang H, Long J, Zheng X, Tian W (2008) Orbital floor reconstruction: a retrospective study of 21 cases. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 106:324–330
18. Wajih WAS, Shaharuddin B, Razak NHA (2011) Hospital universiti sains malaysia experience in orbital floor reconstruction autogenous graft versus medpor. *J Oral Maxillofac Surg* 69:1740–1744