Experimental Use of Autogenous Bone Grafts as an Alternative Method for Bone Plates in Treatment of Mandibular Fracture

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Abstract: Mandibular fractures have a high incidence among facial bone fractures that necessitated prompt treatment. The use of autogenous graft as a fixation device for mandibular fracture may have an important role in bone healing with accepted biological effect, and normal bone growth especially in pediatric patients. Moreover it avoids the side effect of both inter maxillary fixation (IMF) and bone plates. The aim of this study is to evaluate the use of autogenous bone graft for fixation of mandibular body fracture in dogs, both histologically and radiographically. Nine male mongrel dogs were included in this study. Fracture lines were induced in their mandibular bodies followed by their fixation using autogenous bone grafts harvested from fracture sites. The grafts were rotated by 90 degrees to the fracture lines and fixed with 4 bicortical titanium screws at their corners. The radiographic examination is performed at one, three and six weeks after surgery. The animals were sacrificed after six weeks of surgical procedures for histological examinations. Four dogs showed initial healing of induced fracture line with integration of the bone graft to the underlying lingual cortical plate through woven bone formation at six weeks postoperatively. While three animals exhibited failure of the graft to fix the fracture and two cases were excluded from the study due to fracture of the harvested graft during its fixation. It could be concluded that this technique could be an alternative treatment modality in fracture fixation but with favorable fracture with stable bony segment in order to achieve proper bone healing.

Key words: INTRODUCTION

Mandibular fracture is the first or second most common facial bone fracture, occurring as twice as fractures of the midface bones. The incidence is about 38% of all facial bone fractures. This is mainly due to mandibular prominence, relative lack of support, and the weak structures of the condyles, angles and the parasymphysial regions of mandible (De Matos et al. 2010, Patrocinio et al. 2005, Alagoz et al. 2008). Successful treatment of mandibular fractures depends on reduction and fixation for restoration of the normal occlusion, function, and proper alignment of bone using a closed or open technique (Roccia et al., 2005, Ayoub and Rowson 2003, Coburn et al., 2002, Farr and Whear 2002, Holmes and Hutchinson, 2000). Stable intermaxillary fixation (IMF) can be achieved by various techniques but the standard method is the use of arch bars which is applied to both dental arches. In spite of their disadvantages such as the limitation of arch bar with medically compromised patient, its hazards effect on periodontal apparatus, disuse atrophy of muscles, TMJ disorders and weight loss, it is considered the standard method in closed reduction technique for treatment of mandibular fracture (Key and Gibbons, 2000, Majumdar and Brook, 2002, Vartanian and Alvi, 2002).

The primary treatment modality for open reduction is rigid internal fixation using plate and screws. Plate osteosynthesis is an accepted, reliable and well established method for treatment of mandibular fracture that allow primary bone healing. It was introduced in 1886 and since that time, different systems have been developed, such as compression, miniplates, locking and resorbable plates (Alagoz et al., 2008, Roccia et al., 2005). Their aim was to decrease the complication accompanied with rigid fixation. However, many studies as Key and Gibbons, 2001, Majumdar and Brook, 2002 reported general complications range from 3.6% to 21.3%.
for infection; from 0.5% to 1.9% for malunion; 0.5% for delayed union; 2.6% for facial nerve damage and 1.4% to 3.7% for mental nerve damage. In addition, there is an increased complexity and cost as well as an exposure which is necessary for plate insertion and removal leading to further devascularization of bony fragments. Also, bicortical plating has a risk of injury to the inferior alveolar neurovascular bundle, as lag screw does (O’Connell et al., 2009, Fox and Kellman, 2003).

Furthermore, despite of excellent performance of plating system, doubts have emerged about their long-term behavior in tissues and their potential for local and systemic side effects (O’Connell et al., 2009, Langford and Frame, 2002). Branamark et al., in 1977, had proved that titanium dioxide did not produce any toxic reaction. While Katou et al., 1996 and Tomazic et al., 1991, found an association between titanium particle from miniplates and chronic inflammation, encapsulation, monocyte and macrophage activation with the release of bone resorbing mediators. On the other hand, Weingart et al. 1994, reported that although there is an increase of titanium level in lymph node, there is no foreign body reaction.

Using of autogenous bone graft is considered valuable in multiple purposes in maxillofacial region (Ahlmann et al., 2002). Autogenous bone graft can be used for ridge augmentation and reconstruction of mandible after tumor resection with satisfactory results. Smolka et al., 2006 and Alagoz et al., 2008 suggested its use for fracture fixation with proper fracture healing and function performance.

So the aim of the present study is to evaluate the use of autogenous bone graft in fixation of mandibular fracture in dogs both histologically and radiographically.

MATERIALS AND METHODS

Nine male mongrel dogs (canins familiars) were included in this study. The selected dogs were apparently healthy with an average weight of 20 kg and an average age of 1.5 years.

Preoperative Evaluation:
The dogs were examined thoroughly by a veterinary and kept under clinical observation for two weeks preoperatively to make sure that the selected dogs were free from any disease. The animals were housed in separate cages in the animal house of the Faculty of Medicine, Cairo University.

Surgical Procedures:
• Preoperative Preparation:
The animals were starved for 12-24 hours and thirsted for 6 hours prior to anesthesia.

• Induction of Anesthesia:
A mixture of xylocaine HCl 1mg/kg body weight and ketamine HCl 5mg/body weight via a 20 gauge intravenous cannula through the cephalic vein. The respiratory airway was kept patent by applying a nasostrachéal airway.

• Operative Procedure:
Teeth were placed in occlusion using inter dental wiring preoperatively.
The surgery was performed under strict aseptic conditions. The skin of the operated area in submandibular region left side was shaved and disinfected by an antiseptic solution, then isolated by sterile towels. Local anesthesia was injected subcutaneously. A 4 cm submandibular incision 0.5 to 1.0 cm below and parallel to the lower border of the mandible was carried out using a number 24 Bard Parker blade. The deep fascia was dissected, and then the periosteum was reflected to expose the buccal cortical bone anterior to the angle of the mandible.

A square form monocortical osteotomy (1.5 cm x 1.5 cm) was performed on the buccal cortical plate just anterior to the mandibular angle using low speed surgical fissure bur under copious irrigation. The square extends from the alveolar crest above to about 0.5 cm above the inferior border. Bicortical vertical osteotomy was initiated at the middle of the square aiming to produce mandibular fracture along this vertical osteotomy line (Fig.1). Chisels and mallet were used to separate the two rectangular bone blocks from the surrounding bone. As the bone graft was harvested, chisel and mallet were used to complete the fracture of mandible along lingual cortical bone plate.
The two rectangular bone grafts were rotated 90 degrees and used to fix the induced vertical body fracture using 4 bicortical screws (2 mm in diameter and 12 mm in length) at the 4 angles of the square after preparation of their screw beds using long drill bit 1.5 mm in diameter. The screws pass from buccal cortical plate and engage the lingual plate for proper stabilization of graft and retention of screws (Fig.2).
Fig. 1: Two rectangular buccal bone blocks harvested from fracture site.

Fig. 2: Rotation of bone graft 90 degree for fracture fixation using 4 bicortical screws.

The fixation was carried out taking into consideration that the inferior alveolar nerve is kept intact and free inside its canal during bone fracture, harvesting, and fixation without injury. The wound was then thoroughly irrigated using sterile saline solution and closed in layers using 2.0 vicryl sutures for the deep layers and 3.0 black silk sutures for the skin. The inter dental wiring was released before animal recovery. Two cases showed splitting of the graft during its fixation so they were excluded from the study (Fig.3). (Fig.3): Showing fracture of bone graft during fixation

Fig. 3: Showing fracture of bone graft during fixation

Post-operative Care and Follow Up:

The dogs were allowed to recover in a warm place with dry non-slip floor. Afterwards, they were returned back carefully to their cages. The animals were injected IM penicillin streptomycin (2 gm vet preparation) twice daily for three successive days post-operatively to prevent post-operative infection and received voltaren 50 mg IM twice daily for 3 successive days also to control pain. The dogs were examined thoroughly for any late wound complications or delayed reactions. Their appetite was also observed. The dogs were kept on soft diet (bread and milk) for one week and cold cut of meat for the remaining 5 weeks.
**Radiographic Examination:**
Post-operative lateral oblique radiograph was taken at 1, 3 and 6 weeks postoperatively using an extra-oral 10 x 12 inches X-ray film (48 kv, 100 mA, 0.1 sec).

**Animal Scarification:**
Scarification was carried out for all animals after six weeks using an overdose of sodium thiopental through the cannulated cephalic vein for histological examination.

**Histological Preparation:**
Each mandible was dissected free. The mandibular segments enclosing the surgical procedures were dissected. The specimens were then processed as described by Gayle *et al* 2002. Decalcification was performed with a solution containing equal parts of 50% formic acid and 20% sodium citrate. After a complete decalcification, the screws were unscrewed gently. The specimens were then embedded in paraffin wax with a convention technique and serial mesio-distal sections (6 μm thick). The whole surgical area was carried out. These sections were stained with hematoxylin and eosin.

**RESULTS AND DISCUSSION**

**Clinical Observations:**
Clinical examination at 1, 3 and 6 weeks postoperatively revealed that, The animals exhibited proper wound healing, with apparent good general conditions without any signs of infection. Three animals of seven were with quiet behavior and diminished physical activity, while the other 4 were with normal activity.

At 3 weeks postoperatively, bimanual palpation of the fractured sites after animals sedation reveals, loose bony segments across the fracture lines in the three cases, while in the other four animals stable segment without mobility was detected.

**Radiographic Examination:**
Postoperative follow up at one and three weeks, it reveals radiolucent space at the fracture site for all cases. In 3 cases, graft fracture and displacement was detected for animals with diminished activity (Fig. 4) while in the other four cases with normal activity the graft was intact.

At six week postoperatively, there was slight decrease in fracture space in the 4 dogs with intact graft that denotes presence of healing at fracture line (Fig.5).

Fig. 4: lateral oblique view demonstrates wide radiolucent line at fracture site, with graft fracture at three weeks postoperative.

Fig. 5: Radiographic view shows decreased fracture space at 6th week postoperative.
Histological Evaluation:
At 6 weeks postoperatively, all specimens were examined with light microscopic. Four cases showed a greater amount of bone remodeling units, with reversal lines showing bone resorption and new formation on its bony surface. Woven bone formation could be seen at the fracture line, and forming a connection between the original bone and the autogenous graft. Also areas of connective tissue interposed between them were still noted (Fig.6). While the remaining three cases with fractured graft showed wide gap between the bony segments with absence of any indications of healing process.

Fig. 6: A histological examination using light microscope demonstrates formation of woven bone (WB) between graft and original bone (RB) (haematoxylin and eosin ×10).

Discussion:
The goals of mandibular fracture repair are to achieve proper bony union with good dental occlusion, preserve nerve function, prevent post-traumatic complications such as infection, and attain optimal esthetics by maintaining teeth and minimizing external facial scars (Alagoz et al., 2008, Ellis 1999, Wang et al., 1998). Although the intermaxillary fixation alone could full fill this criteria, but open reduction and fixation is accepted treatment modality. The popularity of the rigid fixation depends on patient comfort and satisfaction (Alagoz et al., 2008).

Since 1970s, Numerous plating systems began to emerge but it was proved that fracture healing is a process of restoring the structural and biological properties of injured bone and the success of the plates may be more related to variables in operator application and bone quality rather than to differences in the hardware (De Matos et al., 2010, El-Degwi and Mathog 1993, Reedy and Bartlett 1997). So this study evaluated the use of autogenous bone graft as a fixative device in the treatment of fractured mandibular body in dogs. The advantage of this technique is to reduce infection rates, operation costs, the need for second operation for plate removal and reduction in the amount of foreign materials. This is agreed with one of the main principles in the treatment of the mandibular fractures which is use of the least amount of foreign material (Schierle et al., 1997).

Young animals (1.5 years old) were selected to achieve rapid bone healing of the fracture. Wide autogenous bone graft was harvested from fracture site. It extended from alveolar bone crest to 5 mm above the inferior border of the mandible in order to obtain fixation at superior and inferior borders of fracture along the compression and tension zones of mandible. This is in accordance with the principles of plates fixation that recommend application of 2 titanium plates along fracture line to prevent distraction of the superior border of the fracture line at the tension zone (Albert et al., 2003). Four bicortical screws were used for graft fixation and fracture reduction by engaging lingual cortical bone plate.

At six weeks postoperatively initial bone healing at the induced fracture line was detected through formation of woven bone in 4 cases (the woven bone cannot be seen in x ray that is why the healing of fracture could not be proved on x ray). Inspite of the healing is not completed but presence of woven bone ensure that the mechanism of healing begin and using of graft is valuable in fracture fixation with reduction in hardware complication as reduction in bone properties and absence of osteopenia of the cortices that occur under rigid fixation.

The results of this study agree with that of Alagoz et al., 2008, they used autogenous bone graft harvested from fracture site for fixation of favorable mandibular fracture and iliac graft for fixation of unfavorable fracture accompanied with (IMF). They proved satisfactory results in occlusion, panoramic and CT examinations, except for one case that showed malocclusion with anterior open bite in favorable cases and one case of hypothesia in unfavorable cases. In addition, Kosaka et al., 2004, applied autogenous graft from chin to fix infraorbital fracture and reported that autogenous bone graft fixation provides proper fixation for fracture with ease trimming of graft, absence of function disabilities, no secondary deformity, no visible scars, absence of postoperative complication in fractured site, with no need for second surgery for implant removal.
Moreover, Reedy and Bartlett 1997, stated that using of autogenous bone graft as fixative device has an advantage in pediatric patients with mandibular fracture, for whom titanium plates should be taken out after healing so as not to disturb their mandibular growth.

On the other hand, the incomplete healing of the 4 cases and absence of healing in the other 3 cases in spite of the initial intraoperative stability may be attributed to:

Bone graft may not strong enough to withstand muscular force along the fracture line, where the quality and rigidity of graft depends on its chemical structure of minerals and organic substances. It was reported that application of autogenous graft for fracture fixation is limited on stable fracture segments away from excessive loading for graft healing (Kosaka et al., 2004).

Inability to use IMF in dogs, to improve the fracture fixation, as mouth closure in dogs leads to overheating, hyperthermia and death of the animal (Boudrieau and Michele 1996).

The devascularization of the bone graft that may participate in the failure of healing, where Alagoz, 2008, concluded that both devascularized graft and titanium plate have the same rate of postoperative infection.

Use of four screws only for fixation of graft may not enough to establish proper fixation of graft as seen in the radiographic results with graft displacement and fracture, but in the same time using of more screws in fixation might endanger the graft with its fracture and loss.

Inspite of avoiding the complication of both closed and opened fixation technique with using autogenously graft fixation technique, this technique has some disadvantages that could complicate its use. As increased operation time, especially during bone graft harvesting, there is possibility of graft fracture either during harvesting or fixation, possibility of donor site morbidity and the probability of inferior alveolar nerve damage if care was not taken. Furthermore, bone graft alone cannot withstand masticatory forces especially with unfavorable fractures.

So, with limitation of this study, it could be concluded that this technique could be used for treatment of stable favorable fracture, away from masticatory forces in order to achieve proper healing.

REFERENCES


