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Research Article

The Use of Autogenous Rib Graft in Craniofacial Reconstruction: Case Series Study

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Abstract

Background: Hard tissue defects in the maxillofacial region due to trauma or ablative surgery result in functional and cosmetic problems. The method of choice in the treatment of facial defects is autogenous bone grafts. ***Objectives***: To evaluate the use of rib grafts in the reconstruction of craniofacial deformities. ***Methods***: This prospective study was presented for the reconstruction of craniofacial deformity using a rib bone graft. These cases were collected from the Maxillofacial Surgery Unit from October 2011 to November 2020. The sample consisted of 16 patients (14 males and 2 females, with a mean age of 34 years). The patients were divided according to the site of the defect. In all cases, a single rib was harvested. The fifth rib was taken. Bone graft fixation by bone plate, direct screws, and transosseous wiring. The success of the bone grafting was assessed by clinical and radiological examination. ***Results***: The overall success rate in this study was 87.5%, while we had bone graft resorption in two cases (12.5%) of mandibular reconstruction. Only one case experienced donor site complications, a pleural tear, which successfully underwent suturing and chest tube insertion. ***Conclusions***: Free autogenous rib was successfully used to reconstruct defects in the maxillofacial regions. It gives the best result when minimum loading is needed. Stabilization of the graft by rigid internal fixation and good adaptation to the recipient site helped to minimize complications.

Keywords: Bone Graft, Craniofacial deformity, Craniofacial reconstruction, Rib Graft.

استخدام طعم الضلع الذاتي المنشأ في إعادة البناء القحفي الوجهي: دراسة سلسلة من الحالات

الخلاصة

الخلفية: عيوب الأنسجة الصلبة في منطقة الوجه والفكين بسبب الصدمة أو الجراحة الاستئصالية تؤدي إلى مشاكل وظيفية وتجميلية. الطريقة المفضلة في علاج عيوب الوجه هي ترقيع العظام الذاتية. **الأهداف**: تقييم استخدام الترقيع بواسطة طعم عظم الضلع في إعادة بناء التشوهات القحفية الوجهية. **الطريقة**: تم اجراء هذه الدراسة المستقبلية لإعادة بناء التشوه القحفي الوجهي باستخدام طعم عظم الضلع. تم جمع هذه الحالات من وحدة جراحة الوجه والفكين من أكتوبر 2011 إلى نوفمبر 2020. وتألفت العينة من 16 مريضا (14 ذكرا و2 من الإناث، بمتوسط عمر 34 سنة). تم تقسيم المرضى وفقا لموقع الخلل. في جميع الحالات، تم حصاد ضلع واحد. تم أخذ الضلع الخامس. تثبيت الطعم العظمي بواسطة صفيحة العظام والبراغي المباشرة والأسلاك عبر العظام. تم تقييم نجاح ترقيع العظام عن طريق الفحص السريري والإشعاعي. **النتائج**: كان معدل النجاح الإجمالي في هذه الدراسة 87.5٪ ، بينما كان لدينا ارتشاف طعم عظمي في حالتين (12.5٪) من إعادة بناء الفك السفلي. عانت حالة واحدة فقط من مضاعفات موقع المتبرع، وهو تمزق جنبي، خضع بنجاح للخياطة وإدخال أنبوب الصدر. **الاستنتاجات**: تم استخدام الضلع الذاتي الحر بنجاح لإعادة بناء العيوب في مناطق الوجه والفكين. يعطي أفضل نتيجة عند الحاجة إلى الحد الأدنى من التحميل. ساعد تثبيت الطعم العظمي عن طريق التثبيت الداخلي الصلب والتكيف الجيد مع الموقع المتلقي على تقليل المضاعفات.

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INTRODUCTION

The craniofacial abnormalities arise from the surgical removal of tumors and decompression craniotomies. These individuals experience both functional and cosmetic issues and require reconstructive procedures to restore both functionality and aesthetics [1]. The utilization of various autogenous grafting and alloplastic materials has effectively reduced the functional and esthetic issues linked to these abnormalities and deformities [2,3]. Common alloplastic implants, such as titanium bone plates and screws, are generally well tolerated. However, they can lead to delayed problems, such as implant extrusion or fracture [4]. Autogenous bone grafts have been commonly utilized since the 1900s and are employed in several therapeutic scenarios, such as nonunion, fracture, and joint reconstruction. The rib stands out among autograft sources because to its ability to provide both cartilage and bone, either separately or in combination. The utilization of distinct rib components in grafting is a well-established and fundamental approach in the

reconstruction of the nose, skull, and jaw [5,6]. The graft's ease of manipulation and shaping, along with its minimal risk of problems and donor site morbidity, make it the preferred choice in specific conditions [7]. This study aims to evaluate the use of rib grafts in the reconstruction of craniofacial deformities.

METHODS

Study design and setting

The sample of our prospective study consists of 16 patients. These cases were collected from the Maxillofacial Surgery Unit during the period from October 2011 to November 2020. The patients were 14 males and 2 females, a ratio of 7:1. Their ages range from 23 to 45 years, with a mean of 34 years. We divided the patients according to the site of the defect; we have 7 cases (43.75%) of reconstruction of the mandible, 4 cases (25%), orbital reconstruction, 3 cases (18.75%) of frontal bone reconstruction and 2 cases (12.5%) of nasal bone reconstruction. In all cases, a single rib was harvested. The 5th rib on the right side is taken in 15 cases and in only one case, the 5th rib was taken from the left side.

Preoperative assessments

The general evaluation comprises the adherence to a standardized format for recording the patient's medical history. The information provided encompassed the individual's name, age, gender, occupation, address, general medical background, the underlying cause of the defect, and the duration of its existence. The patient's primary concern and reason for seeking treatment is the remaining problem. The patient underwent a comprehensive clinical assessment in preparation for the surgical surgery. In addition, the suggested investigations were performed, including a complete blood picture, blood group analysis, renal function tests, chest x-ray, and electrocardiography. All of these instances were examined to exclude any potential general medical contraindications for the surgical reconstruction. All common medical issues were addressed appropriately.

Clinical examination

In order to restore the facial flaws, it is necessary to do a thorough clinical and radiological examination and assessment of the patients. The patient's records include the findings from external and internal examinations, which involve inspecting and palpating the areas outside and inside the mouth. The extraoral examination comprises: A) The frontal bone should be inspected for contour depression, flatness, esthetic abnormalities, loss of continuity, scarring, and soft tissue deficit. Examine the supraorbital rim by gently touching it to detect any irregularities in its structure; assess the magnitude of the abnormality. B) When analyzing the orbit, we assess visual acuity, ocular mobility, and the presence of diplopia or enophthalmos. Examine the orbital rims for any irregularities, such as a step-like deformity, and check for any abnormal sensations or numbness in the areas supplied by the infraorbital, supraorbital, and supratrochlear nerves. C) The mandible was analyzed to evaluate the state of the hard and soft tissues, the presence of step deformity, asymmetry, facial nerve function, scar line, and temporomandibular joint. D) The nose was inspected for any imperfections, as well as signs of depression or flattening. Simultaneously, an intraoral examination was conducted to assess the necessity of preoperative interventions such as the alleviation of soft tissue contractures, the identification of exposed teeth at the edges of the bone, the evaluation of dental condition, the assessment of oral cleanliness, and the analysis of dental occlusion.

Radiographic evaluation

Computerized tomography scans (coronal, axial, sagittal and 3D reconstruction) are very useful, especially in the examination of the floor of the orbit, which gives a clear idea about the extent of bone loss and its effect on ocular muscle movement.

Indication of treatment

Orbital defects are addressed to improve both cosmetic appearance and to correct diplopia resulting from a blowout fracture. Frontal bone procedures are performed for cosmetic purposes as well as to provide protection to the brain. Nasal bone augmentation is purely cosmetic in nature. Mandibular reconstruction aims to achieve symmetry and restore missing parts of the mandible, serving both cosmetic and functional purposes (Figure 1).

Types of rib grafts

Two different types of rib grafts were utilized, depending on the specific instance. In frontal bone and nasal bone restoration, a split rib graft was employed in 5 cases. In orbital and mandibular bone reconstruction, a non-split rib graft was used in 11 cases.

Treatment steps

We operated on all patients under general anesthesia, using either nasal or oral endotracheal intubation. All patients received sterile preparations and drapes using the same conventional method. The recipient site was initially exposed. Four patients underwent surgery for orbital defects. There are three cases with orbital floors, one with a floor, and one with a medial wall. The approach was from the midtarsal, infraorbital, and scar; B) mandibular defect; 5) cases body and 2 parasymphyseal. D) Frontal bone defect: In three cases, the surgical approaches were from the scar in the forehead, and one case from a supraorbital incision (Figure 2).

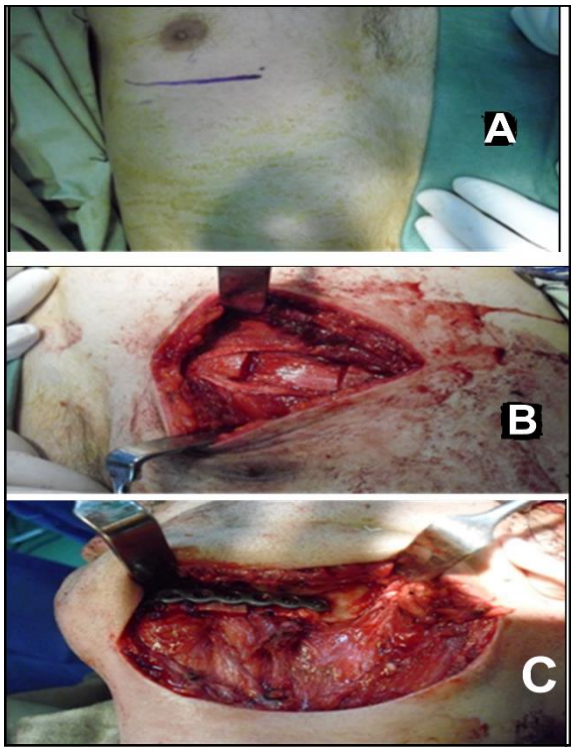

Figure 1: A case of mandibular reconstruction. (A) Performing the incision line at 5th intercostal space. (B) The site after graft removal. (C) Fixation of the graft in the reciepient site (mandible).

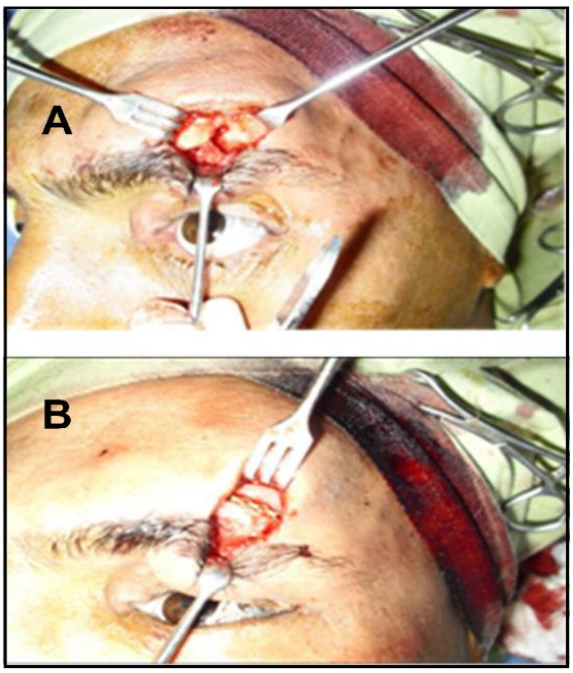

Figure 2: A case of frontal bone reconstruction. (A) Recipient site (supraorbital rim). (B) fixation of the graft (Note the eye is artificial).

The surgeon employed an extraoral submandibular approach, starting with the scar. In two cases, the surgical approach was based on the scar. The incision line marks the donor site in the submammary region, which is characterized by skin fissures. For each patient, we made a cutaneous incision of approximately 5 cm. We extracted the graft and wrapped it in saline-soaked gauze. The anesthetist should maintain positive pressure on the patient during a thorough examination to identify any leaks or bubbles. This is a method of pleural rupture detection. All cases used interrupted sutures to achieve closure. We used a 2/0 polydiaxonone or vicryl absorbable suture material on a round needle to close the inner layers, and a 2/0 nylon interrupted 3/0 silk or subcuticular suture to close the skin. Corrugated drains are only present in two containers. In one instance, a pleural tear necessitates the insertion of a chest tube. The cardiovascular surgeon inserts the tube after suturing the tear under positive pressure. In all instances, dressing was created. We reshaped the extracted bone graft to match the defect's shape and size, then inserted it into the defect. The graft was fixed using a bone plate in 12 cases, a trans-osseous wire (0.5 mm soft stainless steel wire) in 2 cases, and a direct fastener in 2 cases. We dressed and closed the recipient locations. Patients with mandibular bone grafts underwent maxillomandibular fixation for a period of 2-4 weeks.

Postoperative care and follow-up

The patient should be observed for respiratory rate, pulse, and blood pressure every 30 minutes for 4 hours, and then hourly for the first 24 hours postoperatively. A chest radiograph should be taken after patient recovery to exclude pneumothorax. The range of patient stays in the hospital was from 5 to 7 days. During the patients' hospital stay, we primarily administered penicillin derivatives (500 mg Ampicillin+Cloxacillin I.V. injection 4 times daily) and metronidazole I.V. infusion (500 mg 3 times daily) in oral form. Analgesics were used in the form of injectable or oral diclofenac or paracetamol (500 mg). Patients had been instructed to start mobilization early with chest physiotherapy. Passive drains in the donor site were removed after 48 hours. The chest tube was removed after 2 days. The sutures in the recipient site were removed at around 7 to 10 days postoperatively. Those of the donor site were removed at around 10 to 14 days postoperatively. The follow-up period ranged from 1 to 12 months and was programmed as weekly for the first month postoperatively. Over the follow-up period, the patient was evaluated based on osseous continuity, then once per month for the following 3 months and after 6 months and 1 year. Three months following surgery, the graft was evaluated with a plan radiograph according to the site. The clinical suthe defect was eliminated, and both the donor and recipient sites achieved good functional results. Both the donor and recipient sites achieved good functional outcomes after eliminating the defect.

RESULTS

Patients undergoing bone graft reconstruction for facial defects range in age from 23 to 45 years, with an average age of 34 years (Table 1), and Figure 3 illustrates their age distribution.

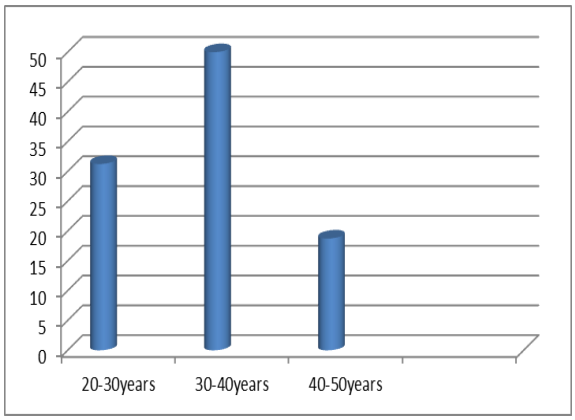

Figure 3: Age distribution of the enrolled patients.

Fourteen of the patients (87.5%) were male, and two (12.5%) were female. The anatomical region distribution of facial defects that required bone grafts was 7 (43.75), and orbit defects were 4 (25%). Table 1 shows that there were 3 frontal bone defects (18.75), and 2 nasal bone defects (12.5%). In terms of the etiology of bone defects, 14 (87.75%) of the cases are traumatic (most of them due to explosive injuries), while 2 (12.5%) of the cases are pathological (mostly due to benign tumors). We used bone plates for 12 (75%), transosseous wires for 2 (12.5%) cases (mandible and nose), and screws for 2 (12.5%) cases (mandible).

Table 1: Demographic and clinical characteristics of the participants.

Variable	Value
Patient age (year; mean)	34(23-45)
Gender distribution n(%)	
Male	14(87.5)
Female	2(12.5)
Etiology of the defect n(%)	
Trauma	14(87.5)
Pathology	2(12.5)
Method of fixation n(%)	
Bone plat	12(75)
Wiring	2(12.5)
Direct screw	2(12.5)
Anatomical region of the defect n(%)	
Mandible	7(43.75)
Orbital	4(25)
Frontal	3(18.75)
Nasal	2(12.5)
Outcome of the surgery n(%)	
Failure	2(12.5)
Success	14(87.5)

In all patients, we used delayed bone graft reconstruction. We used 12 (75%) non-splitted ribs and 4 (25%) split rib grafts for reconstruction at the recipient site. The period of hospitalization was 5-7 days. The complications associated with no grafting include an intraoperative complication in one patient (pleural tear that needs suturing and chest tube insertion); the chest tube was removed after 2 days of surgery. However, non-steroidal anti-inflammatory drugs can manage postoperative mild to moderate pain at the donor site. With the exception of one case, we can mobilize all patients on the same day of operation. Two cases (12.5%) of mandibular reconstruction reported graft failure; they experienced graft resorption, causing the screws and wire to loosen, necessitating the removal of the graft and hardware.

DISCUSSION

The surgeons' preference for different grafting procedures in reconstructing craniofacial defects and deformities of variable etiology depends on many factors, such as the age of the patient, the nature of the defects and their consequent structural, functional, and cosmetic effects, available resources, and personal experience and training. Rib grafts are one of the free, non-vascularized bone and cartilage grafting materials that are versatile in craniomaxillofacial reconstruction. Regarding sex distribution, males form 87.5% while females form 12.5%. Maxillofacial trauma is more common in males than females. The higher proportion of males with a mean age of 34 years may be explained by the fact that this age group represents the time of maximum activity in human life, and males in this age group spend most of their time outdoors. The analysis of the cases presenting with facial deformities aligns with the findings of Carvalho *et al*. (2010) and Costan *et al*. [8,9]. The increase in missile injuries in Iraq over the last ten years and the delay in definitive treatment could be a contributing factor. Patients who have lost portions of their mandibular body need an in-lay bone graft or require an on-lay bone graft for correction of asymmetry in the mandible find the rib to be a more advantageous option due to its shape resemblance, featuring a prominent curve from posterior to anterior. Its suitable thickness and pliability in contouring, derived from a thin layer of cortical bone with a minimal amount of cancellous bone, further enhance its appeal. In five cases of mandibular reconstruction, the graft used as an inlay graft showed good results without any complications. This was attributed to the presence of good bed vascularity, proper orientation of the graft in the recipient bed, the graft being subjected to mechanical stress, and the use of rigid fixation (reconstruction plate and lag screw). These factors are considered crucial in preventing graft resorption, stabilizing the grafted bone through maxillomandibular fixation, and ensuring proper rigid fixation of the graft to the recipient site, thereby allowing bone-to-bone contact. These measures were implemented in all cases with mandibular defects, with the exception of one case due to a severe mandible deformity, in accordance with Collyer *et al*. (2008) [10]. In two cases, bone grafts were used in the mandible as on-lay grafts failed and resorption of the graft occurred. Bone graft resorption may be related to many factors, although the bed was free from infection and had good vascularity. Other things that can cause a graft to fail, like limited mechanical stress and the type of fixation, Bone grafts that were fixed with rigid skeletal fixation formed bone unions, while those that were fixed with wire fixation only formed fibrous unions [11]. In one case, we used transosseous wiring, which may be the cause of bone graft failure, as well as adaptation of the graft to the recipient bed (the graft should be in intimate contact with the bone at the

recipient site). In the second case, there was a gap between the graft and the bone at the recipient site. In this study, the rib was used with a successful outcome in correcting the structural and esthetic components of the nasal deformity, with the advantages of providing flexibility and easy shaping, which are related to the thin cortex and in agreement with the study of Jiang *et al*. [12]. In two cases, the rib graft was used to restore the nasal bridge as an on-lay graft [12]. For the craniofacial surgeon, the surgical repair of large skull defects is still a challenge. In addition to the cosmetic considerations, these defects, when large, leave a significant area of the brain unprotected and are known to be associated with chronic headaches, developmental delay in young children, and the syndrome termed sinking-skin-flap syndrome [13,14]. Cranioplasty using an autologous split rib has been universally accepted as the preferred option for adults and pediatric patients [15]. In this study, we used split ribs that were arranged parallel and in contact with each other, which gave a very good esthetic result and closed the defect totally with good support for the overlying skin. Splitting the rib increases the surface area of cortical bone available for reconstruction and improves vascular ingrowth by exposing the bone's cancellous border to the soft tissues of the recipient site [16]. Our study is in agreement with the results reported by Singh *et al*. (2011) [17], who used the split rib graft procedure without complications of graft failure and achieved a good cosmetic and functional result. Orbital floor reconstruction aims to restore orbital floor continuity, provide support for orbital contents, and prevent soft tissue fibrosis. Different materials have been tested over the years to reach this purpose. Traditionally, autogenous grafts have been used as the material of choice. This study employed rib grafts to reconstruct the orbital floor. The graft's smoothness, malleability, and ease of adaptation to the reconstruction area, stemming from the rib's thin, flexible cortex, align with a previous study conducted by Saluja *et al.* (2017) [18] that utilized autogenous ribs to restore the orbital floor. For the fixation method, we performed rigid internal fixation using a bone plate for 12 cases, along with transosseous wiring for 2 cases and direct screws for 2 cases. We also performed maxillary mandibular fixation in cases of mandibular reconstruction [1]. When a rib graft restores a mandibular defect, the reconstruction of the mandible employs both rigid fixation and maxillary mandibular fixation. So we agree with the results reported by Collyer *et al*. (2008) and Elsalanty (2009) [10,19]. They used rigid fixation and intermaxillary fixation to achieve optimal stability, allowing for vascular ingrowths and graft healing. Schön *et al*. (1997) [20] reported successful results in 12 cases (87.5%), suggesting that miniplate fixation is the preferred method for bone graft fixation. Trans-osseous wiring stabilized in one failure case in this study, aligning with the findings of Valentini *et al*. (2007) [21], who demonstrated that bone grafts with rigid skeletal fixation formed bone union, while those with wire fixation only demonstrated a fibrous union. Two cases used direct screws; one experienced complete resorption due to the graft's inadequate adaptation to the underlying bone. One case demonstrates a high level of graft success, consistent with the findings of Donkor *et al.* (2006) [1], who employed direct screws as a rigid fixation method for rib grafts used as on-lay grafts to the mandible. In all cases, delayed reconstruction was the treatment of choice because of severe injuries in trauma patients that are associated with life-threatening injuries (head injuries). We have two cases of misdiagnosed orbital floor fractures. In the case of traumatic injuries, adequate time elapsed between the injury and the surgical procedure increases the chance of a successful bone graft. In this regard, Castro-Núñez and Van Sickels *(*2017) concluded that delayed reconstruction was superior due to infection [23]. Donor site morbidity is an important factor that must be considered when choosing a bone graft. Only one case (6%) in this study experienced a pleural tear, prompting the insertion of a chest tube as a preventive measure against pneumothorax. This outcome is similar to the findings of Morton *et al*. [24], who considered rib graft cartilage harvest a safe procedure with a low incidence of complications. Another potential risk associated with rib harvesting is the development of a superficial donor site infection, a complication that has not been observed in any of the cases. Good follow-up, daily dressing at the donor site, and postoperative antibiotic cover may contribute to this. All patients had postoperative pain of mild to moderate severity [25]. Most patients achieved control of their postoperative pain with a 75 mg diclofenac intramuscular injection once or twice daily. Early postoperative respiratory physiotherapy did not lead to any postoperative chest infection in any of our patients, contrary to the finding of James and Irvine (1983) [26], which attribute a high postoperative chest infection rate to delayed implementation of effective postoperative respiratory physiotherapy.

Conclusion

A wide variety of maxillofacial procedures can use the rib graft as a safe, well-accepted procedure with relatively low morbidity, and it provides reliable, abundant grafting materials sufficient to successfully reconstruct variable defects in the head and neck region. The split rib bones are reliable grafts in cranioplasty. Large defect reconstruction, such as segmental mandible reconstruction, requires another graft option, such as an iliac bone graft or free flap.

Conflict of interests

No conflict of interests was declared by the authors.

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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