Original Article - Evaluative Study

Anterior Aesthetic Zone Reconstruction with Allogenic Bone Shell and Autogenous Bone Chips - An Evaluative Study

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Abstract

Introduction: Horizontal alveolar bone loss hinders dental implant placement. Reconstruction of alveolar deficiency is mandatory to establish an ideal foundation for implant-supported prosthetic restoration. The aim of this study is to evaluate the regenerated bone following anterior aesthetic zone reconstruction with allogenic bone shell and autogenous chips. **Materials and Methods:** A total of 15 deficient sites in the aesthetic zone were treated using allograft bone shells, which were fixed away from the alveolar ridge using microscrews, and the created gap was filled with autogenous chips harvested intraorally using a bone scraper. **Results:** Clinically, one patient experienced wound dehiscence in the second post-operative week, and the graft had to be removed one month postoperatively due to infection. Three patients experienced shell detachment six months later but that did not hinder the placement of an implant. Radiographically, there was horizontal bone gain that was statistically significant six months postoperatively. The mean apical bone gain was 2.64 mm (±0.99 standard deviation [SD]). The mean mid-level bone gain was 3.44 mm (±0.52 SD). The mean crestal bone gain was 2.36 mm (±0.85 SD). Histologically, vital trabecular bone tissue with osteocytes and osteoblasts was detected. Moreover, the presence of reversal lines indicated bone formation and remodelling after grafting. **Discussion:** This technique generates sufficient bone tissue in previously horizontally deficient alveolar ridges for subsequent implant placement and omits the need for a second surgical site with its consequent morbidity. The low complication rate reported needs further modifications to extrapolate results.

Keywords: Allograft shell, autogenous chips, aesthetic zone, horizontal augmentation, Khoury shell technique

Introduction

Horizontal alveolar bone loss hinders dental implant placement. Reconstruction of alveolar deficiencies before implant surgery using autogenous block graft is still considered to be the gold standard.[1] Khoury F. and Khoury CH. made a variation by splitting the solid bone block into two thinner shells, so more vascular chips can be packed in between the bone shell and the alveolar ridge.[2] Khoury shell technique has received wide interest since its inception.[2-9] Khoury and Hanser explained this technique using specific equipment in addition to possible complications related to the donor site,[5] which made many practitioners not use this technique. The aim of this study is to evaluate the regenerated bone following anterior aesthetic zone reconstruction using Khoury shell technique with allogenic bone plate and autogenous bone chips.

Materials and Methods

This study was designed as a prospective evaluative study and carried out in line with the principles of the Declaration of Helsinki and in accordance with the STROBE guidelines.

Fifteen adult patients with a total of 15 implant placement sites were enrolled in this study between April 2018 and November 2018. Clinical trials registration number was NCT04324697, and ethical committee clearance number was OMS03M/78/2018.

Inclusion criteria were patients within the age range of 18–50 years and with a horizontal alveolar bone deficiency in the anterior maxilla which needed bone grafting for subsequent single implant placement, normal bite and occlusion. Exclusion criteria were history of intravenous and/or oral bisphosphonate use, irradiation of the head-and-neck region,

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infection, pregnancy, immunocompromised and medically compromised (such as diabetics) patients and smokers.

Pre-operative phase

A detailed history was collected from each patient. After a thorough intraoral examination of hard and soft tissues, study models were prepared and articulated to evaluate inter-arch space and analyse the occlusion with respect to the site of the future implant. Prophylactic oral antibiotic (amoxicillin/clavulanic acid 875 mg/125 mg) was prescribed every 12 hours for two days preoperatively and chlorhexidine hydrochloride 0.125% mouthwash three times daily to decrease gingival inflammation. Cone-beam computed tomography (CBCT) was used to evaluate the linear measurements of the defect width before augmentation. The measurements were made at three levels: apical level (measurement 1/M1), mid-level (measurement 2/M2) and crestal level (measurement 3/M3).

Surgical phase

The field of surgery was scrubbed with antiseptic solution. The surgical procedures were carried out under local anaesthesia using articaine 4% with adrenaline 1:100,000. A mid-crestal incision was placed over the edentulous site and was extended with sulcular incision to include the adjacent teeth, with vertical releasing incision distal to the neighbouring tooth on each side. After reflecting a full-thickness mucoperiosteal flap, periosteal scoring (horizontal periosteal releasing incisions) was done first before the augmentation which is important to facilitate the primary closure in a tension-free manner. Autogenous bone chips were harvested intraorally using a bone scraper (Safescraper Twist, Divisione Medicale, Italy) from the canine eminence and/or the anterior nasal spine according to availability, with no need for a second surgical site [Figure 1a and b]. The recipient site was fenestrated several times using a small round burr to induce bleeding points to improve blood supply.[10] The allograft shell (Maxgraft® Cortico, Botiss Biomaterials GmbH, Berlin, Germany) was not kept in any kind of solution (antibiotic or saline) before fixation according to the manufacturer's recommendations. The allograft shell was adjusted to the recipient site using a periodontal probe as a reference, from its original manufacturer dimensions (25 mm × 10 mm × 1 mm), and secured in position labially by means of two microscrews (1.2 mm diameter), ensuring a gap between the graft and the residual native bone to be filled with the harvested autogenous chips [Figure 1c]. Average length of 7-8 mm for screws were used depending on the defect morphology, with the length divided as 2–3 mm engaged to the residual native bone, 1 mm holding the allograft shell and the remaining length of screw within the created gap of 3 mm, plus avoidance of overscrewing. The space of created gap was checked using a periodontal probe. Sharp edges of the allograft shell were smoothened, and the autogenous chips were packed into the gap to reconstruct the site [Figure 1d]. The flap was sutured using 3-0 Vicryl suturing material. Patients were instructed to continue the oral antibiotic for three days postoperatively[11] and to take diclofenac potassium 50 mg oral tablet, every 8 hours for three days, and thereafter if needed for pain relief and anti-inflammatory effect.

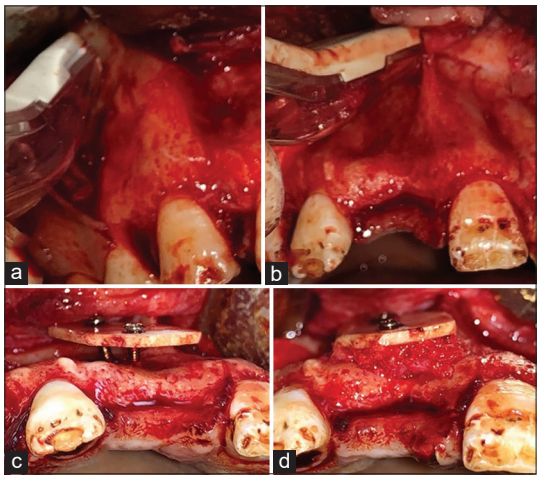

Figure 1: Surgical phase; (a) Harvesting autogenous chips from canine eminence, (b) Harvesting autogenous chips from the anterior nasal spine, (c) Fixation of the allograft plate with microscrews, (d) Filling the gap with autogenous chips

Post-operative phase

Clinical evaluation was scheduled weekly for the first month and then again at three months to assess pain according to the Visual Analogue Scale[12] and correlating it to oedema [Table 1] and for any signs of infection or wound dehiscence. During the healing period, the patients were advised not to use a removable prosthesis.

A CBCT obtained after six months was used to compare the new width of the alveolar ridge to the pre-operative width [Figure 2]. Measurements were standardised using a stable reference point on the contralateral tooth (tooth apex). All data were tabulated for statistical analysis.

Statistical analysis

It was performed with GraphPad Prism version 8.2.1 (GraphPad Software, San Diego, California, USA). Paired *t*-test was used to compare the alveolar width measurements at the pre-operative and post-operative stages. The significance level was set at 5% level ($P \leq 0.05$).

Stage II surgical phase

Six months postoperatively, a full-thickness flap was raised using one releasing incision to ensure complete attachment of the allograft shell to the underlying bony tissue. This phase

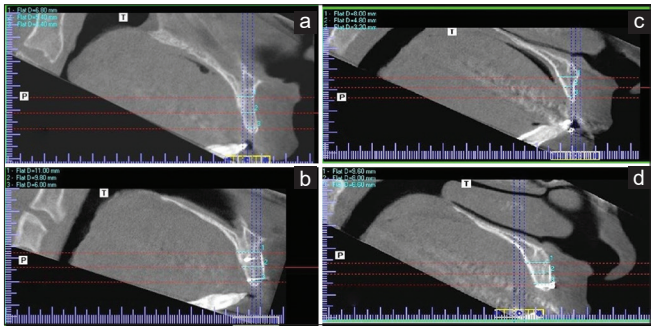

Figure 2: Radiographic evaluation (a) pre-operative and (b) post-operative measurements for same case, (c) pre-operative and (d) post-operative measurements for another case

included mainly: (a) removal of the fixation screws, (b) biopsy for histological evaluation from the grafted bone area using a hollow trephine burr (2.3 mm diameter) instead of the initial implant drill before implant placement [Figure 3] and (c) placing the dental implant. The final prosthetic restoration was placed after 3 months.

The bony core biopsy was fixed in a solution of 10% buffered formalin and decalcified in EDTA for 4 weeks. It was then processed by routine histological procedures to obtain paraffin-embedded tissue sections (5µ thickness). These sections were subjected to haematoxylin and eosin staining in order to assess and describe the quality of the bone.

Results

Demographic variables data was tabulated [Table 2]. Twenty-eight patients were screened, and 15 met the inclusion criteria. The reasons for exclusion were smoking, pregnancy or the patients' decision to not have an implant. The study included nine (60%) female and six (40%) male patients, with a mean age of 26.8 (±6.09) years.

Table 1: Visual Analogue Scale for pain and oedema assessment

Scale	Description	
	Pain	Oedema
0 - no	The patient feels well	No detectable The slightest swelling
1 - slight	If the patient is distracted, he/she will not feel pain	The patient detects a slight swelling, but unnoticeable
2 - mild	The patient feels the pain even if concentrating on some activity	Swelling is noticeable, but not a problem
3 - severe	The patient is very disturbed but continues with normal activities	Swelling is evident and hinders normal perioral expressions
4 - very severe	The patient is forced to abandon normal activities	Swelling is marked with no perioral expressions
5 - extremely severe	The patient must abandon every type of activity and feels the need to lie down	Swelling is very marked with superior and lateral extension

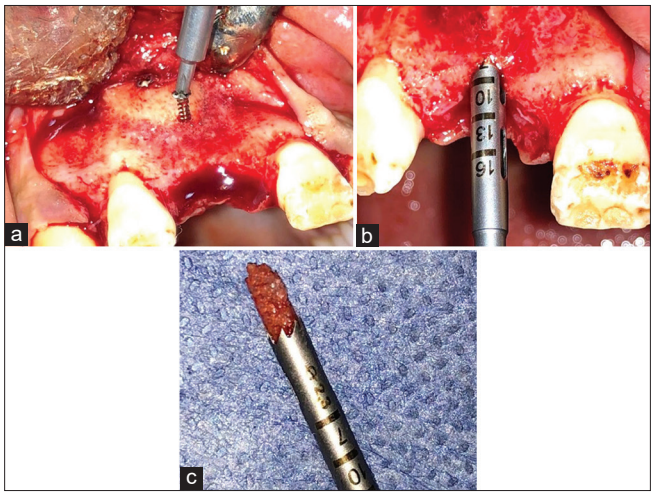

Figure 3: Stage II surgical phase: (a) Removal of fixation screws by raising a full-thickness flap, (b) The trephine burr instead of the initial implant drill, (c) Bone core biopsy for histological examination

Upon clinical assessment [Table 3], one patient who had severe oedema in the first week required prescription of an anti-oedema medication (two tablets every 8 h for three days). The oedema reduced significantly at two weeks postoperatively and was associated with wound dehiscence. One month postoperatively, the graft had to be removed due to infection. Six months postoperatively, three patients experienced shell detachment, but this did not hinder the placement of the implant. No adjunctive soft-tissue augmentation procedures was required or carried out during or after prosthetic stage.

Radiologically, the difference between the alveolar bone measurements pre-operative and at six months postoperatively [Table 4] was statistically significant ($P = 0.0004$ for apical level; $P < 0.0001$ for mid-level and $P = 0.0003$ for crestal level).

Histological evaluation revealed the presence of newly formed healthy bone in the specimens with evidence of osteoblast on the periphery and osteocytes in their lacunae inside the bone trabeculae [Figure 4]. Moreover, the presence of scalloped reversal lines revealed the change from bone resorption to bone deposition and straight resting lines reflect a rhythmic bone deposition process, and all of them reveal the success of lamellar bone matrix formation after placement of the graft [Figure 4].

Discussion

Alveolar bone in the anterior maxilla is rapidly resorbed after extraction of natural teeth, even if the alveolus is intact. There is a 40%–50% decrease in the alveolar width within the first six months.[13,14] Alveolar ridge reconstruction with autogenous bone block graft is considered to be the gold standard.[1] The main intraoral donor sites for autogenous bone block are the symphysis and retromolar region. Gulinelli *et al*. reported in a study to evaluate the reconstruction of atrophied anterior maxilla with

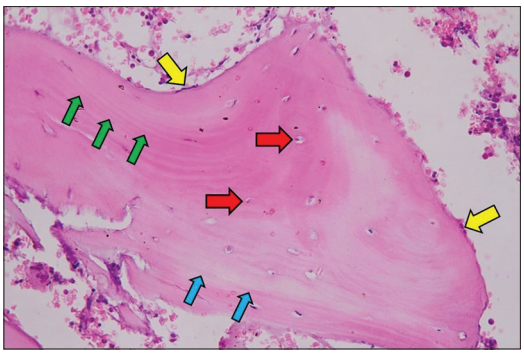

Figure 4: Photomicrograph showing the presence of osteoblast on the bone trabeculae periphery (yellow arrows) and lacunae of osteocytes showing trapped osteoblasts (red arrows), scalloped reversal lines inside the trabeculae (green arrows) and the straight resting lines (blue arrows) (H and E, ×400)

autogenous bone block that the mean bone width preoperatively was 3.8 mm crestally and 5.7 mm apically in the upper region.[15] These measurements are very close to our study where the mean bone width preoperatively was 3.61 mm crestally and 5.29 mm apically. Their results revealed that the mean bone width six months postoperatively was 7 mm crestally and 8.3 mm apically in comparison; our study showed that the mean bone width six months postoperatively was 5.96 mm crestally and 8.09 mm apically.

The variation of autogenous bone block from retromolar region was achieved by splitting the solid bone block into two thinner shells as described by Khoury F. and Khoury Ch.[2] Stimmelmayr *et al.* showed promising results of the shell technique for horizontal ridge augmentation in 22 patients.[7] They reported an increase in the mean crestal bone width from 2.7 mm to 5.9 mm (preoperatively to a mean healing period of 5.5 months postoperatively, respectively), compared to our presently reported 3.61 mm to 5.96 mm (preoperatively to six months postoperatively, respectively). They also reported a slight resorption of the graft width with a mean resorption of 0.8 mm (±0.5 mm standard deviation). They recommended that the ridge should be overcontoured due to the resorption, and we tended to follow their recommendation of slight overcontouring. The presence and probability of donor site morbidity and intraoperative and post-operative complications are still present as described by Khoury and Hanser.[5]

The use of allograft material in ridge augmentation is well documented and has shown results similar to autogenous graft harvested from the mandible.[16-19] Sterio *et al.* used cancellous allograft particulates in their study with a resorbable collagen membrane for horizontal augmentation in the anterior maxillary region.[19] They analysed the mean alveolar ridge width at two levels – at 3 mm apical and at 6 mm apical to the bony crest. Corresponding to the measurement levels in our study, we can consider the crestal level and the mid-level with their levels, respectively. Their results showed that the mean bone gain six months postoperatively was 1.65 mm crestally and 1.93 mm at the mid-level, while in our study, the mean bone gain was 2.36 mm crestally and 3.44 mm at the mid-level.

A drawback of our study is that alveolar bone width measurements immediately postoperatively were not recorded to determine the resorption rate. All patients in the present study showed remarkable resorption of the allograft shell crestally, six months postoperatively at the time of implant placement. We considered from the clinical point of view that the resorption rate ranged crestally from 1 to 1.5 mm, as the allograft shell thickness is 1 mm. We believe that this resorption crestally is due to the early revascularisation and regeneration of vital bone from the packed autogenous chips[2-4] and the nature of the allograft shell used, which was demineralised freeze-dried bone allograft (DFDBA) according to the manufacturer. DFDBA has a rapid resorption phenomenon due to the loss of most of the mineralised components but the retention of osteoinductive proteins and growth factors.[20,21] In respect of the osteoinductive properties of DFDBA and the high vascularity of the maxillary bone, it is

Table 2: Demographic variable data

Variable	Frequency (%)
Sex	
Male	6 (40)
Female	9 (60)
Age (years)	
20–24	6 (40)
25–29	3 (20)
30–34	6 (40)
Grafting site	
Upper central incisor	9 (60)
Upper lateral incisor	6 (40)
History of tooth extraction	
Traumatic	5 (33.3)
Non-traumatic	10 (66.7)

Table 3: Clinical assessment

Clinical variable	1 week post-operative			2 weeks post-operative			1 month post-operative	3 months post-operative
	Patients	Scale	Percentage	Patients	Scale	Percentage		
Pain	4	1	26.7		None		None	None
	3	2	20					
Oedema	5	1	33.3	1	2	6.7	None	None
	1	3	6.7					
Infection		None			None		1 patient	None
Wound dehiscence		None			1 patient		1 patient	None

Table 4: Minimum, maximum, mean and standard deviation of the alveolar bone measurements

	Pre-operative (mm)			6 months postoperatively (mm)			Bone gain (mm)		
	M1	M2	M3	M1	M2	M3	M1	M2	M3
Minimum	3.20	3.50	3.00	6.40	6.50	5.50	1.30	3.00	1.00
Maximum	8.00	5.40	4.60	11.0	9.80	6.60	4.20	4.40	3.40
Mean±SD	5.29±1.52	4.25±0.63	3.61±0.59	8.09±1.64	7.74±1.10	5.96±0.37	2.64±0.99	3.44±0.52	2.36±0.85

M1: Apical, M2: Mid-level, M3: Crestal, SD: Standard deviation

advisable to place the implant four months postoperatively in an attempt to preserve the grafting dimensions.

There are several studies which concluded that the addition of bovine bone material and/or collagen membrane could minimise graft resorption during the healing.[9,18,22] Moreover, graft thickness can be increased or in other words overcontoured to compensate for resorption[23] by controlling the length of the screws used in order to increase the created space for the packed chips between the shell and the native bone but should be within the limits of achievable, tension-free soft-tissue coverage.

The surgical technique is very sensitive using this kind of allograft shell, however promising and reliable the results for implant placement and the level of patient satisfaction. The allograft shell is brittle and can be cracked and/or fractured easily. In order to overcome that it should be handled carefully using graft holder, drilled outside the field and avoid overscrewing the shell during fixation. In all presented cases, the allograft shells were fixed using two titanium microscrews actively holding the shell to prevent microrotation of the graft, which may result in compromised healing as mentioned by many authors.[3,24]

Based on this technique, healing of grafted sites was reported to be normal with minimal occurrence of complications presenting mostly as superficial epithelial sloughing and re-epithelialisation being complete two weeks later,[8] wound dehiscence, graft exposure[6,7] and infection.[7] In the present study, only one patient experienced wound dehiscence and graft exposure in the second post-operative week. The wound was irrigated every day for two weeks, and additional oral antibiotic and antiseptic mouthwash were prescribed for one week in an attempt to facilitate healing by secondary intention. The graft had to be removed one month postoperatively due to infection. It is probable that wound breakdown was due to the extent of post-operative oedema, which was severe one week postoperatively in this patient and also due to the activity of perioral muscles. Tension at the wound margins may be the cause of the wound breakdown as documented in the literature,[6,7] but we tend to disagree with that as all surgeries were done by the same surgeon following the same surgical protocol. Contrary to previous studies of this technique using autogenous shell, we reported shell detachment in three cases, however, this did not hinder the placement of dental implants.

All trephine core bone biopsies were taken from the occlusal aspect of the grafted sites in order to preserve the integrity of labial and palatal bone for implant placement, thereby preserving the integrity of the allograft plate. Harvesting a bone core biopsy through the labial (allograft) plate to assess its histological features would have created a fenestration defect unnecessarily jeopardising osseointegration as well as the aesthetic outcome. Based on the histological findings of this study, the presence of trabecular bone with osteocytes and osteoblasts in the prepared sections is indicative of bone vitality and vascularity. Furthermore, the presence of reversal lines is a sign of bone formation and turnover. All these features could rate the healed graft site highly, further potentially enabling healing processes around the implant postoperatively in terms of Osseointegration.

Conclusion

The shell technique using allograft cortical shell and autogenous chips generates sufficient bone tissue in horizontally deficient alveolar ridges for subsequent implant placement and omits the need for a second surgical site with its consequent morbidity. The surgical procedures and healing period were characterised by a low complication rate. Therefore, we recommend that the healing period or duration from grafting to implant placement should be reduced from six months to four months in order to preserve graft dimensions, thereby reducing the overall treatment time for the patient. Further studies using larger sample size with longer follow-up are needed to confirm the present observations. Also further studies using modifications such as a mixture of 50:50 ratio autogenous scrapings and another slowly resorbing graft material, or studies using a collagen membrane over the graft are needed to be compared with this study.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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