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Article · April 2016

DOI: 10.1016/j.ijom.2015.11.001

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Int. J. Oral Maxillofac. Surg. 2016; 45: 535–544
http://dx.doi.org/10.1016/j.ijom.2015.11.001, available online at http://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Clinical Paper
Pre-Implant Surgery

Simultaneous implant placement with ridge augmentation using an autogenous bone ring transplant

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M. Omara, N. Abdelwahed, M. Ahmed, M. Hindy: Simultaneous implant placement with ridge augmentation using an autogenous bone ring transplant. Int. J. Oral Maxillofac. Surg. 2016; 45: 535–544.

Abstract. The severely defective socket, in which implant placement within the remaining bone will result in a significantly off-axis implant position, precludes immediate implant placement and requires bone grafting as an initial surgical intervention. The aims of this study were to evaluate autogenous chin bone ring consolidation after the augmentation of severely defective sockets and the clinical application of these rings in the premolar–molar region with simultaneous implant placement in a one-stage procedure. Ten patients with 12 defective sockets were included. Sockets were prepared with a trephine bur. Bone rings with a tapped implant osteotomy were harvested from the chin with a larger trephine bur. Bone rings were fitted in the prepared sockets. An implant drill was used to prepare the bone apical to the ring through its central osteotomy. Implants were screwed through the rings and the apical bone. Patients were examined clinically and radiographically immediately and at 6 months postoperative. Crestal bone changes were measured and evaluated statistically. All grafted sockets showed bone healing with no significant crestal bone resorption and no infection; only one ring showed dehiscence, which healed during the follow-up period. All implants showed radiographic evidence of osseointegration. The autogenous chin bone ring augmentation technique was found to be a reliable alternative method for the management of severely defective sockets.

Key words: ridge augmentation; bone ring; immediate implant.

Accepted for publication 4 November 2015
Available online 28 November 2015

Defective sockets resulting from either periodontal disease or surgical trauma during extraction may have an insufficient quantity of bone for successful implant placement. Several classifications of post-extraction sockets in relation to immediate implant placement have been reviewed in the literature; Salama and Salama have classified extraction sockets

into four classes according to the degree of severity of the buccal wall defects.[1]

A number of techniques have been described for the augmentation of defective sockets for implant placement either in a simultaneous approach or a consecutive approach. These include socket preservation, guided bone regeneration, and localized horizontal ridge augmentation using titanium mesh and onlay bone grafting.[2–6] Socket preservation and guided bone regeneration have shown successful results in immediate implant placement for class I and class II sockets of the Salama classification.[7] However, sockets of class III and class IV are severely compromised, with partial or total loss of the buccal plate of bone, and implant placement within the remaining bone would result in a significantly off-axis implant position. In such cases, immediate bone grafting with delayed implant placement has been necessary to solve this problem.[1]

Autogenous corticocancellous chin bone grafts, either in the form of blocks or particulates, have been used successfully for the augmentation of localized alveolar defects. There is experimental evidence that intramembranous bone grafts undergo less resorption than endochondral grafts when used in an onlay technique, based on the more rapid revascularization and similar embryonic origin (ectomesenchyme) of the donor and recipient sites, which enhance early healing.[8–10] Several studies have reported the use of a trephine bur in the chin region for ridge augmentation. These have shown excellent results in relation to implant success and survival rates, with minor complications in terms of damage to the local anatomical structures such as the teeth, nerves, muscles, and vasculature and infection in the donor site area. It has also been stated that incisions in the labial vestibule rather than a sulcular approach allows preservation of the crestal bone and a more secure closure with reapproximation of the mentalis muscle, resulting in a lower risk of chin ptosis.[11–18]

The chin bone disc was first introduced to the surgical field by Watzak et al. for the bony closure of oro-antral fistulas.[19] The chin bone disc was recently modified to a ring shape for the three-dimensional augmentation of defective sockets in the maxillary incisor region with simultaneous implant placement; this technique proved successful in bone augmentation and implant integration.[20–22]

The aims of this study were to evaluate the consolidation of autogenous chin bone rings radiographically after three-dimensional augmentation of severely defective sockets and the clinical application of these rings in the premolar–molar region with simultaneous implant placement in a one-stage procedure.

Materials and methods

Inclusion and exclusion criteria

A prospective study was conducted on a consecutive series of 10 patients. All selected patients had fresh defective extraction sockets in the mandibular premolar–molar region in which the buccal bone was severely compromised and implant placement within the remaining bone would have resulted in a significantly off-axis implant position. The alveolar bone surrounding the extraction sockets was defective either due to periodontal disease or traumatic extraction.

Patients with any systemic disease that could affect bone healing were excluded from the study.

Materials

Schilli Implantology Circle implants were used in this study (SIC invent AG, Basel, Switzerland). Three types of implant drill were employed: classical, crestal, and tapping. The trephine burs utilized in this study were supplied with diameters (internal diameters) of 3.0 mm (2.3 mm), 4.0 mm (3.3 mm), 5.0 mm (4.2 mm), 6.0 mm (5.2 mm), 7.0 mm (6.1 mm), 8.0 mm (7.1 mm), 9.0 mm (8.0 mm), and 10.0 mm (9.0 mm) (Dentium Co., Ltd, Gyeonggi-do, Korea).

Preoperative preparation and radiographic examination

A thorough preoperative assessment of all patients was carried out, including history-taking and clinical and radiographic examinations.

Cone beam computed tomography (CBCT) (SCANORA 3D with AutoSwitch; Soredex, Helsinki, Finland) with exposure parameters of 85 kVp, 15 mA, and 6 cm field of view (FOV), was performed to determine the following: (1) linear measurements of the defective socket (recipient site) including its width, depth, and height, the amount of remaining bony surfaces, the amount of remaining apical bone, and its relationship to the mandibular canal; (2) linear measurements of the chin area as a donor site to identify the area from which the graft could be harvested to meet the socket dimensions (width, depth, and height), without harming the adjacent vital structures.

The measurements were obtained using the following protocol[23,24]: (1) The OnDemand software MPR screen (multiplanar reformatting) was chosen for interfacing (OnDemand3D software, version 1.0.9; Cybermed Inc., Korea). (2) Adjustments were made to the orientation axis so that the axial cut was made parallel to the occlusal plane at the alveolar crest level. (3) Adjustments were made for the coronal cut by rotation of the axial image until the orientation axis was perpendicular to the buccal cortex. (4) Adjustments were made such that the orientation axis of the sagittal cut was midway between the buccal and lingual cortices. (5) Measurements of the buccolingual dimension were done on the coronal section, measurements of the craniocaudal dimension on the sagittal section, and measurements of the mesiodistal dimension on the axial section. (6) The measurements were done along the orientation axis to ensure standardization of the procedure. The slices revealing the maximum dimensions of the defective socket, as well as those revealing the maximum dimensions of available bone at the donor site, were used for the measurements (Fig. 1).

Surgical procedure

All patients were instructed to use povidone iodine mouth rinse (Betadine) before the surgical procedures. All procedures were carried out under inferior alveolar nerve block anaesthesia with mepivacaine hydrochloride and 1:200,000 adrenaline solution (Scandonest 2%; Septodont, France).

A three-line pyramidal flap was incised around the defective socket with subsequent reflection of a full thickness buccal mucoperiosteal flap. A minimal lingual reflection was performed for better exposure of the defective socket walls. The socket was prepared with a trephine bur of outer diameter similar to the socket diameter, guided by the preoperative plan of ridge augmentation and the selected implant diameter and length (Fig. 2).

In the chin region, an intraoral unilateral small vestibular incision was made 3 mm below the attached gingiva. Then the flap was dissected and reflected with partial preservation of the muscle attachment. Based on the preoperative CBCT planning, the selected chin area was outlined monocortically with a trephine bur of sequentially larger diameter than that utilized in the preparation of the socket, creating what is called a chin disc (Fig. 3). An implant osteotomy was performed in the centre of this disc utilizing successive drills

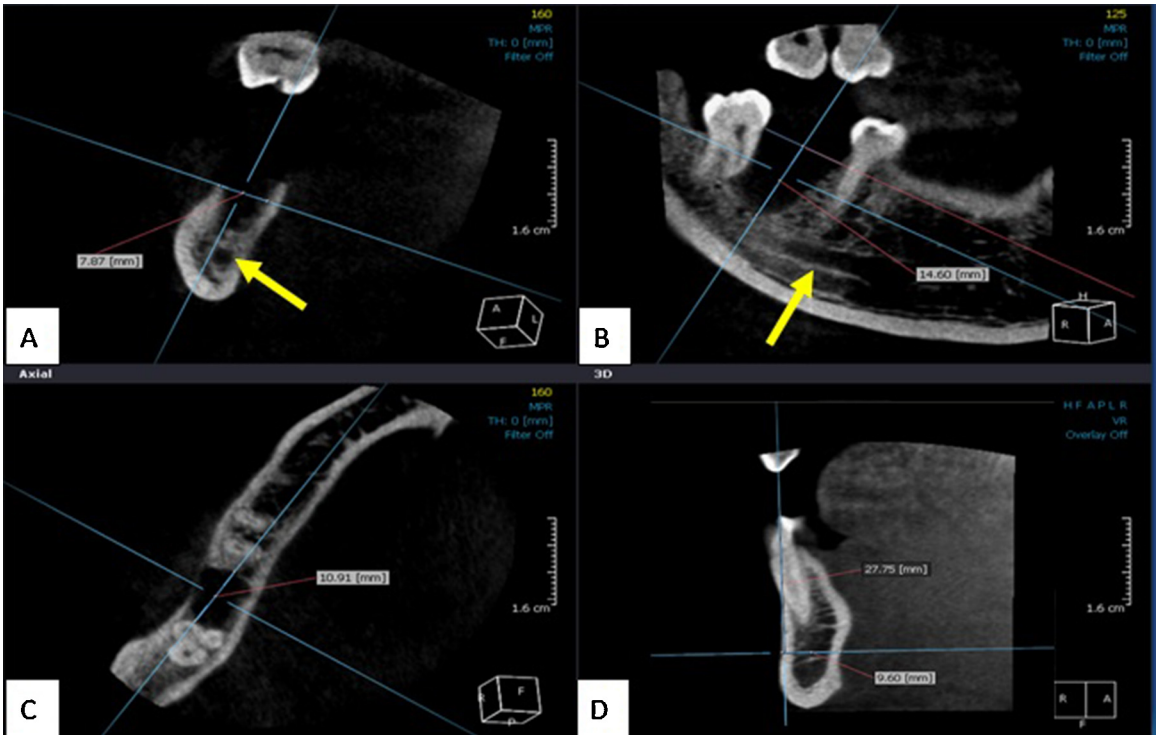

Fig. 1. Snapshot of the MPR (multiplanar reformatting) screen showing the preoperative assessment of defect dimensions. (A) Depth as the buccolingual dimension in the coronal slice. (B) Length as the craniocaudal dimension in the sagittal slice. (C) Width as the mesiodistal dimension in the axial slice. (D) Three-dimensional reconstruction of the defect area. The relationship to the canal is also evident (yellow arrows).

corresponding to the planned implant length and diameter, with preservation of at least 2 mm of normal intact bone around the implant osteotomy. The central osteotomy was then tapped using a special tapping drill through the entire length of the bone ring to prevent it from fracturing at the stage of implant installation (Fig. 4A and B). Harvesting of the bone ring was completed bicortically using the same trephine bur that was used to outline it. The trephine bur was penetrated into the bone, and then smooth cutting was possible. To avoid choking of bone inside the trephine bur, the trephine bur was pulled up and down. Adequate cooling and a low speed of 2000–3000 rpm are recommended to avoid heat damage to the bone.[6,12] Finally, the entire ring was either pulled out simultaneously with the trephine bur during its withdrawal, or was removed with the aid of the tapping drill (Fig. 4C and D). The harvested ring was kept in normal saline and the flap was closed tightly in layers.

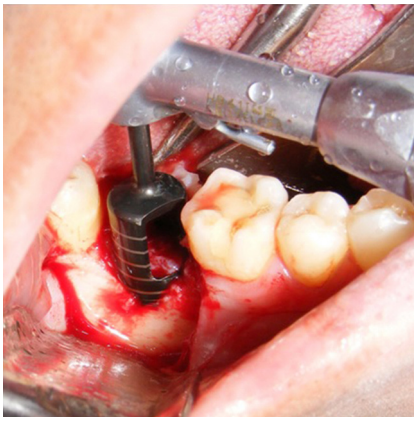

Fig. 2. Clinical photograph showing the preparation of the defective socket using a trephine bur.

The customized bone ring was introduced into the prepared defective socket under delicate pressure utilizing a small bone mallet, augmenting it three-dimensionally; the ring was positioned such that it was 1–2 mm above the adjacent socket walls to compensate for the anticipated bone resorption (Fig. 5A). After ring placement and immobilization using a pickle fork, the final implant drill was introduced through the central osteotomy of the bone ring to prepare the remaining apical bone of the socket for at least 3 mm. The implant was then screwed passively through the tapped central osteotomy of the harvested ring and firmly into the prepared bone apical to the ring using a torque ratchet. The platform of the implant was positioned 1 mm below the surface of the ring to compensate for the anticipated crestal bone resorption. Finally, the covering screw was secured and the ring margin was rounded using a small egg-shaped bur. The flap was relaxed through scoring of the periosteum and then advanced and closed (Fig. 5B).

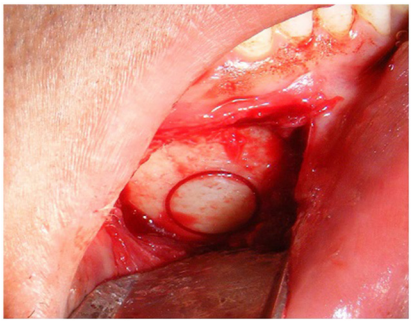

Fig. 3. Clinical photograph showing the outlined bone graft.

Postoperative instructions

After closure of the wound, a pressure band was applied to the chin and cheek areas for 48 h postoperatively. The patients were then instructed to apply ice-packs over the chin and cheek area for 20 min every hour for 6 h postoperatively and to rinse their mouth with warm saline solution starting on the second day

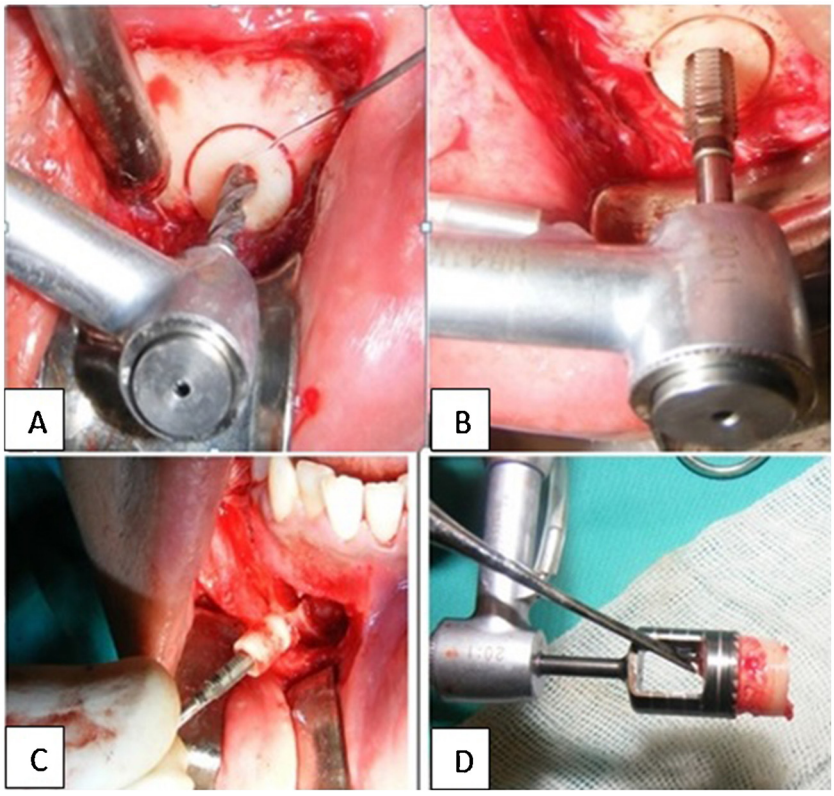

Fig. 4. Clinical photographs showing (A) preparation of the central osteotomy with successive implant drills; (B) preparation of the central osteotomy using the final tapping drill; (C) ring withdrawal with the aid of the final tapping drill; (D) complete withdrawal of the ring within the trephine bur.

after surgery, three times per day during the first week postoperative. The patients were kept on a soft diet for the first 48 h. Postoperative antibiotic, analgesic, and anti-inflammatory drugs were prescribed for 5–7 days. Postoperative follow-up to evaluate wound healing at both the donor and recipient site was carried out every day for the first week and then every month for 6 months. Also all patients were checked for the presence or absence of pain, numbness, swelling, infection, haematoma, and bleeding at both the donor and recipient site.

Postoperative radiographic assessment

During the follow-up period, CBCT scans were obtained immediately (within 1 week) and 6 months postoperative for the measurement of crestal bone height, bone density at the ring–implant interface, and bone density at the ring–alveolus interface.

Protocol for image (slice) adjustment

Using the OnDemand software, the implant was used as a reference point. In the coronal section (showing the buccolingual dimension), the orientation axis of the sagittal slice was adjusted to coincide with the long axis of the implant and bisect it. The orientation axis of the axial slice was adjusted to be at the level of the implant apical end and at a right angle to its long axis (tangential to the implant apical end).

In the sagittal section (showing the mesiodistal dimension), the orientation axis of the coronal slice was adjusted to coincide with the long axis of the implant and bisect it. The orientation axis of the axial slice had already been adjusted in the previous step to be at the level of the implant apical end and at a right angle to its long axis.

Measuring the crestal bone height

In the coronal section, a straight line was drawn just parallel to the implant long axis from the crest of the bone ring buccally to the point of intersection with the axial orientation axis and perpendicular to it. The height obtained was recorded in millimetres. The same process was repeated for the lingual side.

In the sagittal section, a straight line was drawn just parallel to the implant long axis from the crest of the bone ring mesially to the point of intersection with the axial orientation axis and perpendicular to it. The height obtained was recorded in millimetres. The same process was repeated for the distal side.

The measurements obtained from the immediate postoperative CBCT scan were compared to those obtained from the CBCT scan done at 6 months postoperative to evaluate the amount of crestal bone resorption (Fig. 6).

Measuring bone density at the ring–alveolus interface

This applied to the mesiodistal aspects only due to the buccal wall being severely defective in all cases, as mentioned above in the inclusion criteria.

In the sagittal section, a straight line was drawn just parallel to the bone ring at the line of the interface between the alveolar bone and the ring mesially; the mean bone density obtained was recorded in Hounsfield units (HU) (making use of the region of interest (ROI) tool included in the

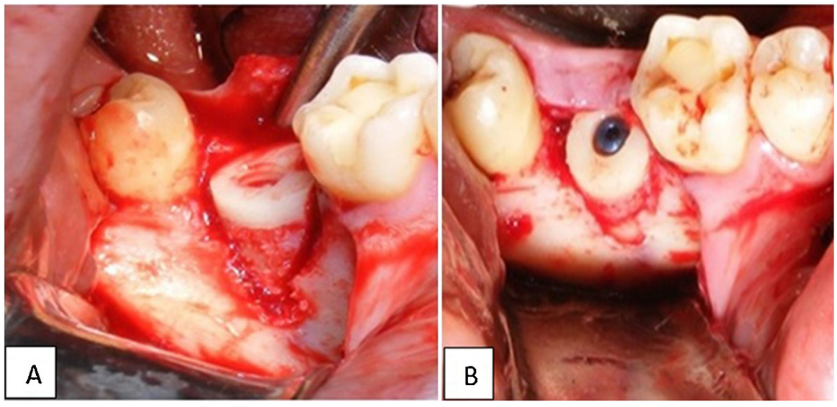

Fig. 5. Clinical photographs showing (A) the bone ring after placement in the prepared socket, augmenting the socket and its defective walls in three dimensions; (B) the implant installed inside the bone ring.

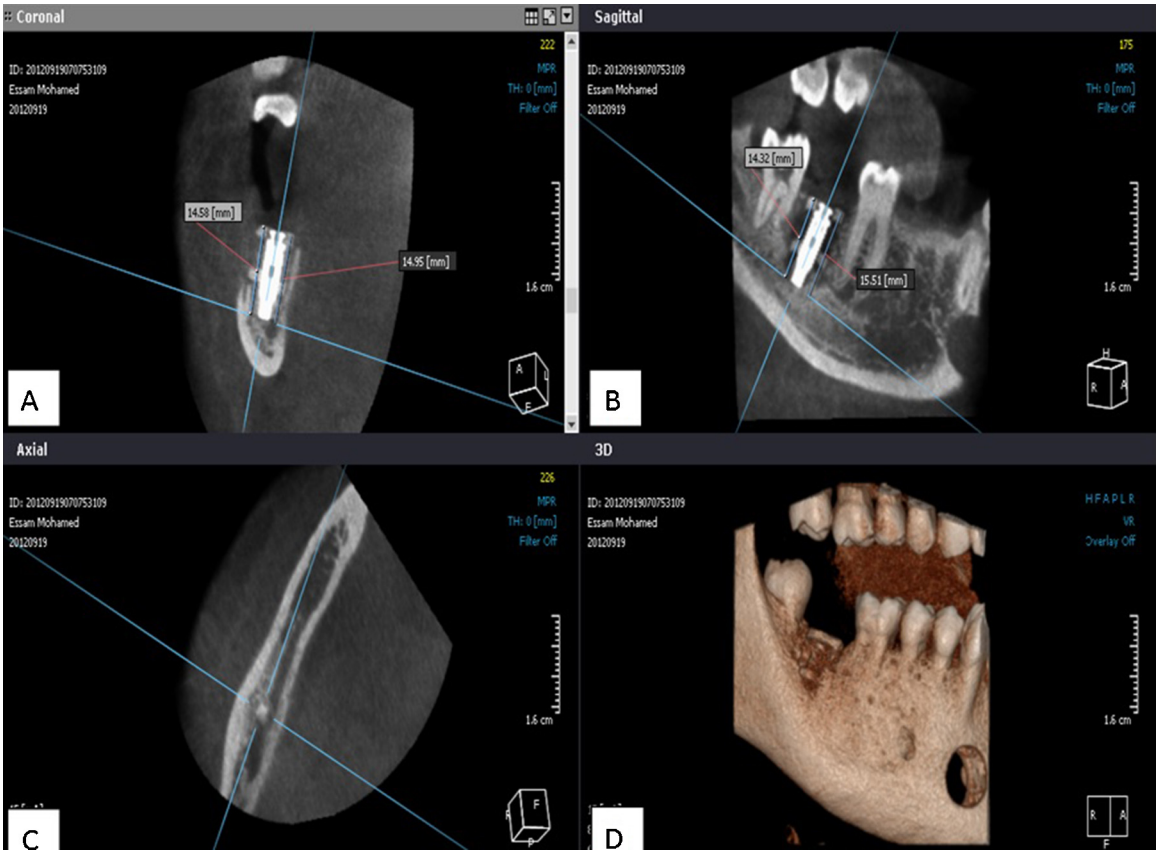

Fig. 6. Snapshot of the MPR (multiplanar reformatting) screen showing the postoperative assessment of crestal bone height. (A) Height measurements for both the buccal and lingual aspects. (B) Height measurements for both the mesial and distal aspects. (C) Adjusted orientation axes in the axial slice. (D) Three-dimensional reconstruction of the grafted bone ring.

software). The same process was repeated for the distal side.

The measurements obtained from the immediate postoperative CBCT scan were compared to those obtained from the CBCT scan done at 6 months postoperative to evaluate the improvement in healing of the bone ring with the adjacent alveolar bone (Fig. 7).

Measuring bone density at the ring–implant interface

In the coronal section, a straight line was drawn just parallel to the implant from the crest of the bone ring buccally to the apical end of the ring; the mean bone density obtained was recorded in HU (making use of the ROI tool present in the software). The same process was repeated for the lingual side.

In the sagittal section, a straight line was drawn just parallel to the implant from the crest of the bone ring mesially to the apical ring end; the mean bone density obtained was recorded in HU (making use of the ROI tool present in the software). The same process was repeated for the distal side (Fig. 7).

Statistical analysis

All data were subjected to statistical analysis. The statistical analysis was performed using IBM SPSS version 20.0 software (IBM Corp., Armonk, NY, USA). Data were represented as the mean $\pm$ standard deviation (SD). The one-sample Kolmogorov–Smirnov test was used to examine the normality of the data distribution. The one-sample *t*-test was used to compare specific variables to a constant value. The paired-sample *t*-test was used to compare scale data within the studied group of patients.

Prosthetic phase

Six months postoperatively, a minimal crestal incision was performed under local anaesthesia and a small flap was reflected to expose the covering screw. The healing abutment was then secured and the flap closed around it to give a natural gingival appearance after healing. After 1 week the healing abutment was removed and the transfer abutment was secured. The impression was then taken to construct the final restoration. Finally, the fabricated ceramo-metallic crown was permanently cemented over the final abutment.

Results

This study included a total of 10 patients (six males and four females) with an average age of 31 years (range 20–43 years). All patients selected had severely defective extraction sockets in the mandibular premolar–molar region (three premolars and nine molars) (Table 1).

Clinical findings

A total of 13 rings were harvested. Five rings were passively pulled out of the chin simultaneously with trephine bur withdrawal. Six rings were removed with the aid of the anchored taping drill; two of them were found to be attached to the genial muscles and were dissected using a sharp periosteal elevator. One ring showed cleavage at the junction of the outer cortical bone leaving the remaining part of the ring in place during trephine bur withdrawal, which made it necessary to harvest another ring from the contralateral

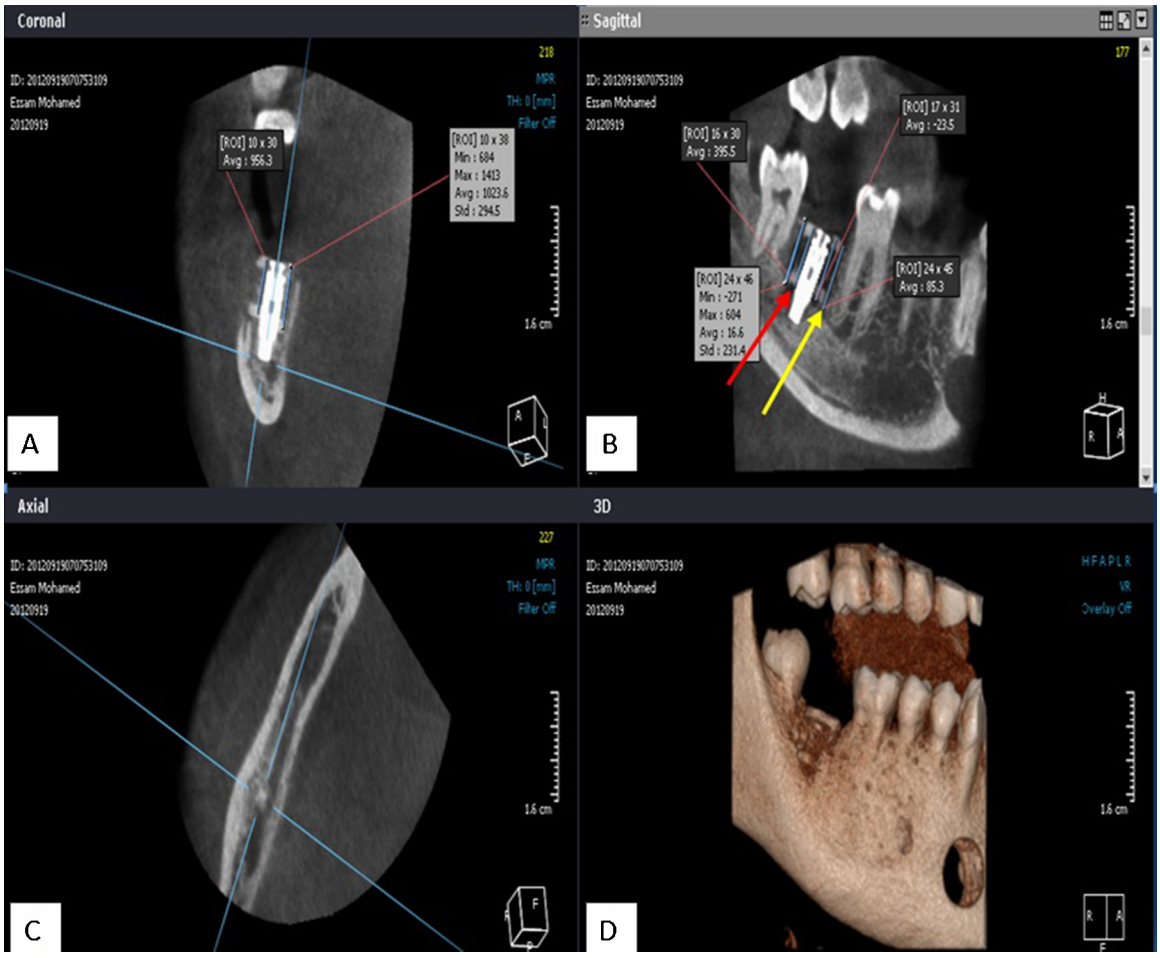

Fig. 7. Snapshot of the MPR (multiplanar reformatting) screen showing the postoperative assessment of bone density. (A) Bone density at the ring–implant interface for both the buccal and lingual aspects. (B) The red arrow indicates the bone density of the ring–implant interface and the yellow arrow indicates the bone density of the ring–alveolus interface for both the mesial and distal aspects. (C) Adjusted orientation axes in the axial slice. (D) Three-dimensional reconstruction of the grafted bone ring. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

side based on the radiographic data obtained from the CBCT.

Three rings were 7 mm in diameter with a 3.5-mm central osteotomy and nine rings were 9 mm in diameter with a 4-mm central osteotomy; the average length was 6–10 mm. The harvested rings fitted perfectly into the prepared defective sockets without any need for re-contouring or adjustment, and the implants were installed passively gaining their primary stability from the remaining apical bone of the sockets. No implant–ring complex showed any degree of mobility at the end of implant installation. However, the ring in the first case was untapped and subsequently cracked during the implant installation; this case was completed and the implant–ring complex healed successfully (Fig. 8).

Wound healing at both the donor and recipient site was optimal in all patients,

Table 1. Demographic characteristics of the study patients.

Patient number	Sex	Age (years)	Number of sockets
1	Male	35	One socket: lower right second molar
2	Male	20	Two sockets: lower right second premolar and second molar
3	Female	30	Two sockets: lower left first and second molars
4	Male	43	One socket: lower right second premolar
5	Female	29	One socket: lower right second premolar
6	Female	42	One socket: lower left second molar
7	Male	21	One socket: lower left first molar
8	Male	27	One socket: lower left first molar
9	Female	27	One socket: lower right first molar
10	Male	29	One socket: lower right second molar

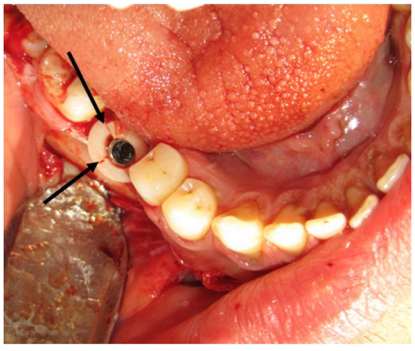

Fig. 8. Clinical photograph taken using a mirror, showing the only ring that cracked during implant placement.

without any signs of infection. Mild postoperative oedema was noted in all patients, which had resolved completely by the recall visit at 1 week postoperative. Two cases suffered from transient numbness of the lower lip, which disappeared by the fourth week postoperative. The cracked ring showed graft dehiscence on the second day postoperatively, which healed spontaneously by secondary intention after smoothing of the lingual sharp edge and using chlorhexidine mouth wash (Fig. 9).

The implants were surgically exposed for superstructure construction 6 months postoperatively. The 12 implants showed a normal healing appearance, with complete coverage of the healing screw by bone for three implants. The other cases showed varying degrees of minimal bone resorption (Fig. 10).

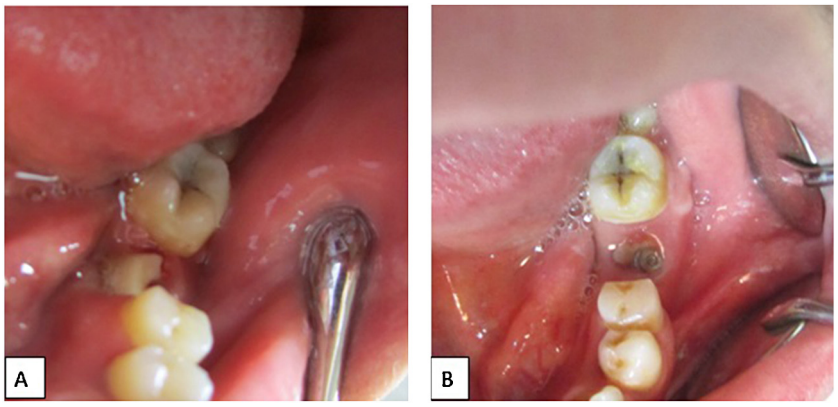

Fig. 9. Clinical photographs showing (A) graft dehiscence immediately postoperative; (B) healing by secondary intention at 2 months postoperative.

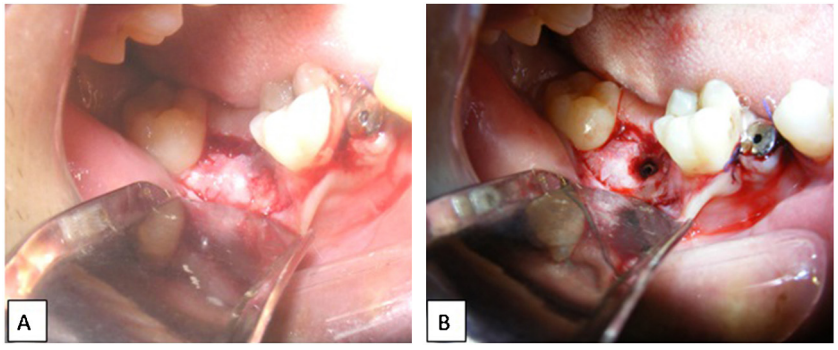

Fig. 10. Clinical photographs showing the healing phase. (A) Complete coverage of the covering screw by bone. (B) Appearance of the buried covering screw after removal of the excess bony coverage.

Radiographic findings

Immediately postoperative, the bone ring outline could be seen, augmenting the sockets in three dimensions and creating new buccal walls where these had been severely defective after extraction. Radiographic images of the bone rings obtained at 6 months postoperative showed that the radiopacity of their outer and inner cortices and the intermediate spongiosa were indistinguishable from the surrounding bony trabeculae, with a homogeneous appearance for seven rings. Two rings showed a decreased radiopacity of the outer and inner cortices and increased radiopacity of the intermediate spongiosa. Three rings showed no radiographic changes.

The difference in bone ring height measured immediately postoperative and at 6 months postoperative was not statistically significant, with a mean crestal bone resorption of 0.2604 mm ($P = 0.321$) (Fig. 11A) (Table 2). The bone density at the ring–alveolus interface showed a statistically significant increase for both the mesial and distal aspect (mean bone density change of 420.43 HU mesially and 325.28 HU distally) (Fig. 11B) (Table 3). Bone density at the ring–implant interface showed a statistically significant increase for both the mesial and buccal aspect (mean bone density change 393.21 HU mesially and 429.69 HU buccally), while the change was not statistically significant for the distal and lingual aspects (mean bone density change 282.60 HU distally and 263.86 HU lingually) (Fig. 11C) (Table 4).

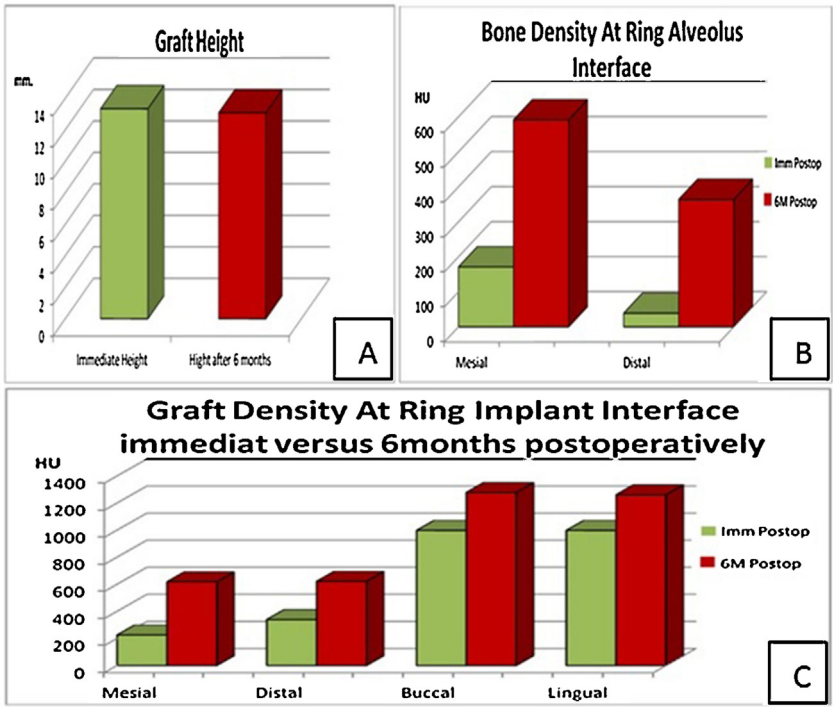

Fig. 11. Graphs showing (A) the average bone height immediately postoperative and at 6 months postoperative; (B) bone density at the ring–alveolus interface immediately postoperative versus 6 months postoperative; (C) bone density at the ring–implant interface immediately postoperative versus 6 months postoperative.

Discussion

The quantity and quality of bone necessary for successful implant placement is

Table 2. Bone height and crestal bone resorption (millimetres).

	Minimum	Maximum	Mean	SD	*P*-value
Immediately postoperative	11.84	15.15	13.3363	1.23058	0.321
6 months postoperative	10.69	14.86	13.0758	1.37821	
Amount of bone resorption	−1.93	0.94	−0.2604	0.86855	0.321
Percentage of bone resorption	−12.73	6.77	−1.8932	6.40528	0.328

SD, standard deviation.

limited in defective sockets. The Salama classification of extraction site defects emphasizes the effect of the degree of the buccal wall defect and its relationship to implant placement and adjunctive augmentation techniques.[1] Socket preservation and guided bone regeneration have proved to be successful only in the management of Salama class I and class II defects with delayed or immediate implant placement.[7] Moreover, the process of osseointegration might be hindered by the alloplastic materials used in these techniques.[25,26] However, in Salama class III and IV defects, the sockets are severely compromised with partial or total loss of the buccal plate of bone, and implant placement within the remaining bone would result in a significantly off-axis implant position. Several techniques aimed at solving this problem have been reported. Titanium mesh augmentation techniques have proved to be unpredictable due to vulnerability to wound dehiscence with subsequent resorption and substantial pseudo-periosteum formation beneath the mesh.[27] Concerning onlay bone graft techniques, the bone graft is cut without any sculpturing to fit the bony defect, with subsequent delays in graft healing and the stimulation of graft resorption due to the lack of close proximity to the graft bed. Moreover, in all onlay grafting techniques, a secondary surgical intervention is required for delayed implant placement after graft consolidation.[3]

The pioneer work reported by Stevens et al.[20] and Giesenhagen and Yüksel[21] in 2010, in two case reports of defective anterior sockets augmented with simultaneous implant placement using chin bone rings, prompted this study to evaluate chin bone rings clinically and radiographically as a technique for the three-dimensional augmentation of severely defective sockets in the mandibular premolar–molar region with simultaneous implant placement in a one-stage procedure.[20,21]

The chin bone graft is derived from intramembranous bone, which shows less resorption than grafts derived from endochondral bone. Moreover, the chin area contains more cancellous bone than other intraoral sites, thus providing a greater amount of osteoprogenitor cells.[28–30] Furthermore, membranous bone grafts do not present a physical barrier to rapidly ingrowing local vessels, and revascularization proceeds faster than in endochondral cortical bone with a thicker cancellous component.[31] Another important factor is that the harvesting of a bone ring from the chin region is more convenient than from other intraoral donor sites, and such rings can be utilized universally for intraoral augmentation of up to 6 mm or more in three dimensions.[18]

In the current study, chin bone exposure using a conservative unilateral vestibular approach and layered flap closure, followed by immediate postoperative pressure band application, ensured proper

Table 3. Bone density at the ring–alveolus interface (Hounsfield units).

		Minimum	Maximum	Mean	SD	*P*-value
Mesial aspect	Immediately postoperative	−152.50	752.80	171.17	276.88	0.002
	6 months postoperative	210.60	1406.10	591.60	364.00	
	Amount of density change	−236.30	1292.00	420.43	360.66	0.002
	Percentage of density change	−773.90	2978.45	375.04	979.88	0.103
Distal aspect	Immediately postoperative	−533.60	725.30	38.90	298.43	0.002
	6 months postoperative	43.10	799.80	364.19	271.24	
	Amount of density change	31.00	798.80	325.28	272.45	0.002
	Percentage of density change	10.27	4491.72	950.27	1565.61	0.014

SD, standard deviation.

Table 4. Bone density at the ring–implant interface (Hounsfield units).

		Minimum	Maximum	Mean	SD	*P*-value
Mesial aspect	Immediately postoperative	−452.50	1001.00	224.72	470.29	0.008
	6 months postoperative	70.70	1001.00	617.94	329.74	
	Amount of density change	−160.20	1089.20	393.21	421.52	0.008
	Percentage of density change	−41.70	1376.23	274.33	353.54	0.003
Distal aspect	Immediately postoperative	−199.50	853.00	339.14	357.927	0.056
	6 months postoperative	51.10	1819.30	621.74	517.730	
	Amount of density change	−389.80	1112.70	282.60	457.48	0.056
	Percentage of density change	−20.18	514.39	100.62	121.09	0.001
Buccal aspect	Immediately postoperative	568.60	1220.80	848.79	208.93	0.024
	6 months postoperative	248.80	2439.90	1278.48	530.61	
	Amount of density change	−834.40	1309.60	429.69	571.12	0.024
	Percentage of density change	−77.03	173.67	51.52	64.70	0.002
Lingual aspect	Immediately postoperative	566.10	1941.80	997.44	410.13	0.098
	6 months postoperative	656.80	1947.20	1261.30	410.97	
	Amount of density change	−555.20	1381.10	263.86	505.57	0.098
	Percentage of density change	−28.59	243.97	25.60	62.27	0.082

SD, standard deviation.

mentalis muscle reattachment, normal chin appearance, and minimal postoperative oedema in all cases.[16,17] Regarding graft harvesting, appropriate preoperative radiographic planning of the chin area as a donor site allowed the precise determination of the area from which the graft could be harvested to coincide with the socket dimensions (width, depth, and height) and without harming the adjacent vital structures. An end-cutting trephine bur design was used and the trephination protocol that was followed prevented heat damage to the bone and allowed safe graft harvesting. During the outlining of the chin ring it is extremely important to adjust the longitudinal axis of the trephine bur to be perpendicular to the outer cortex of the chin in order to obtain an absolutely cylindrical bone ring. Another important factor is to ensure that the centralization of the implant osteotomy in the ring is parallel to the longitudinal axis of the ring. Both of these factors, together with proper angulation of the trephine bur during preparation of the premolar/molar socket walls, ensures proper implant placement in relation to the opposing dentition.

Graft/bed proximity was achieved in this technique through preparation of the defective sockets using a trephine bur sequentially smaller than the bur that was used to harvest the bone ring, thus allowing the bone ring to be fitted snugly in its recipient site with adequate stability and maximum surfaces of bony contact. This was directly reflected in the early graft healing with subsequent decrease in graft resorption and is in accordance with the findings of Marx, who emphasized the importance of graft stability during the early phases of bone healing and the reflection of this on early vascularization and graft incorporation.[32]

All bone rings were placed in the defective sockets and the implants screwed in without cracking, with the exception of one ring. This one ring cracked because its central osteotomy was prepared without tapping. The tapping drills of the selected implant system were utilized only to provide a central implant osteotomy site of minimal difference to the implant diameter, which facilitated passive implant placement without cracking and without rotational or torque forces on the bone ring. Meanwhile, the apical basal bone of the socket was only prepared with a final classical drill in order to obtain adequate primary stability of the implant–ring complex.

All cases showed optimum soft tissue healing at the grafted socket without any signs of infection or wound dehiscence, except in the case of the cracked ring where dehiscence occurred on the lingual side. This was most likely due to the sharp edge of the ring and the thin lingual mucosal coverage, which was prevented in the subsequent cases through smoothing of the ring margin.

The statistical increase in bone density at the ring–alveolus and ring–implant interfaces and the minimal crestal bone resorption in the linear measurement during the follow-up period reflected the good incorporation of the intramembranous chin bone ring due to rapid angiogenesis,[9,10] with subsequent consolidation of the bone ring into the adjacent alveolar bone and integration of the installed implant into the healed ring. The radiographic changes in bone trabeculation were further evidence of the progression of healing of the bone ring in the socket bed and subsequently served as a positive parameter for implant integration, and these changes were correlated to the clinical findings.

The findings of the current study showed the autogenous chin bone ring augmentation technique to be a reliable and technically applicable alternative method for the three-dimensional augmentation of severely defective sockets with simultaneous implant placement in a one-stage procedure. Furthermore, this technique reduced the treatment period to only 6 months, from the beginning of surgery to the patient receiving the final restoration. A long-term study is proposed to evaluate the implant durability after loading.

Funding

This study was self-funded. There are no financial relationships between the authors and any manufacturer/supplier of any commercial products or services related to this work.

Competing interests

The authors declare that they have no significant competing financial, professional, or personal interests that might have influenced the performance or presentation of the work described in this manuscript.

Ethical approval

All patients were selected from the outpatient clinic of the Department of Oral and Maxillofacial Surgery, Faculty of Oral and Dental Medicine, Cairo University. The present study was approved by the Ethics Committee of the Faculty of Oral and Dental Medicine, Cairo University.

Patient consent

Written consent was obtained from all patients for the use of their clinical photographs as a scientific demonstration in this paper.

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