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Assessment of Dimensional Ridge Changes After Augmentation Using External Oblique Ridge with or without Computer Surgical Guide

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ABSTRACT

Purpose: The current study was conducted to evaluate, clinically and radiographically, the results of defective ridge augmentation by external oblique ridge graft with or without the use of computer-generated surgical guide. **Patients and methods:** Twelve patients with alveolar ridges defect were included in this study. The patients were divided into 2 groups: Group A; The alveolar ridges defect augmentation from external oblique ridge graft using Khoury technique with computer- designed generated surgical guides. Group B; The alveolar ridges defect augmentation from external oblique ridge graft using traditional Khoury technique. Clinical and radiographic follow up was performed for 6 months. Treatment changes were evaluated for each group and a comparison was done between the 2 groups. Data were analyzed using paired t-test for each group and student t- test to compare between the two groups. **Results:** There was a significant increase in bucco-lingual/palatal ridge dimensions between the two studied groups. While the minimal bone distances to the nerve differ significantly ($p<0.05$), the computer guided group had greater amount of bone remaining around the nerve than non-guided group. **Conclusion:** Computer assisted surgical guides allow for accurate precise osteotomies providing safe and quick surgery that reflects positively on the postoperative clinical outcomes.

KEYWORDS

Alveolar Augmentation,
External Oblique Ridge,
Surgical Guide

INTRODUCTION

The atrophy of residual alveolar ridge is chronic, irreversible, progressive and cumulative. Its rate is variable among the individuals and even within one and the same person at different times or in different

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regions within the jaw [1]. Alveolar bone is formed of intra-membranous bone formation, and consists of two components: alveolar process of the maxilla and mandible that provides structural support for the dentition, and alveolar bone proper that lines the socket of the tooth provides an attachment site for the periodontal ligament and its associated structure[2].

Bone remodeling is an active and dynamic process in which the bone is deposited and resorbed by the action of osteoblasts and osteoclasts respectively, in a correct balance, allowing bone tissue to fit to different physiological conditions and to replace damaged bone with newly-formed bone[3].

The autogenous bone was the most proper grafting material as a result of being osteoinductive, osteoconductive and osteogenic properties[4]. The sites of autogenous bone graft can be extraoral or intraoral. Extraoral sites include the iliac crest, tibia, and calvarium, while intraoral sites are zygomatic, maxillary, mandibular and retromolar areas [5]. Intraoral grafting has more advantages over extraoral due to the surgical procedures that can be carried out in the clinic and general anesthesia is elective[6,7]. The mandibular ramus area has been designed as an ideal donor site as it provides dense bone with adequate volume for placement of the implant and rapid healing time; more over it was associated with lower morbidity [8].

In 2007 a new method for grafting ridge defect was introduced using thin cortical plates harvested from retromolar area in order to facilitate the correct three dimensions (3D) placement of dental implants [6]. Many surgical complications during bone harvested from retromolar area have been reported such as unintentional impairment of the inferior alveolar nerve (IAN), cutting, tearing, or laceration of the IAN. These neurosensory disturbances may be due to retraction of the neurovascular bundle in various ways mainly medial to the mandibular ramus and morphological variations of the mandibular canal [9].

Conventional methods for reconstruction of alveolar defects by autologous bone grafts were effective and have shown good success. However, the bone remodeling; which is the most important factor in reconstructive surgery; requires precise techniques in planning to maintain and restore the natural appearance of the jaws and facial structures[10]. The recent imaging techniques, software, computer technologies, and the computer-aided surgeries (CAS) have been widely used for minimizing the surgical risks and improving the precision of surgeries [11]. CAS reduces the surgical time, also may lead to a better outcome for the patient[12]. The idea is relying on the cone-beam computed tomography (CBCT) imaging and fabrication of the computer-generated surgical guide which improves the performance and recognition of the expected anatomy; this was given an accurate preoperative diagnosis and careful pre surgical planning [13, 14].

PATIENTS AND METHODS

Study Design

A prospective study was conducted on a consecutive series of 12 patients with alveolar ridges defect. They were selected from outpatient clinic of Oral and Maxillofacial Surgery Department, Faculty of Dental Medicine for Girls, Al-Azhar and from Shebin Elkom Teaching Hospital. This study was approved by the Research Ethics Committee (REC), Faculty of Dental Medicine for Girls, Al-Azhar University (code: REC-SU-21-02). All patients were informed about procedure details and signed a consent form that they accepted to be involved in the study. The patients were divided into 2 groups: Group A; The alveolar ridges defect was augmented by autogenous bone graft harvested from external oblique ridge using Khoury technique with the use of surgical guides. Group B; The alveolar ridge defects were augmented by autogenous bone graft harvested from external oblique ridge using Khoury technique without using the surgical guides.

Inclusion and Exclusion Criteria

All selected patients had edentulous area with deficiencies of the alveolar ridge in horizontal and/or vertical plan, sufficient bone quantity and quality in the donor site of the mandible (external oblique ridge), free from soft tissue or dental pathology and adequate oral hygiene. Patients with any systemic disease that could affect bone healing were excluded from the study.

Patient Management Protocol

All the patients, in both groups, were subjected to:

1. Pre and postoperative intra and extra oral clinical examinations of recipient and donor sites which included: Ridge contour and relation with adjacent teeth, recording any sign/symptoms of infection, soft tissue evaluation of the vestibular depth, palpation over the covering mucosa was done to detect sharp ridges, tender areas or extremely thin mucosa, and, evaluation of inferior alveolar nerve function.
2. Preoperative, immediate and 6 months postoperative CBCT scans were taken for all the patients in both groups.

Preoperative Planning and Simulation for Computer Assisted Group (Group A)

All the patients in this group underwent preoperative maxillofacial CBCT scans for assessment of bone dimensions and planning for harvesting procedures. The Digital Communication in Medicine (DICOM) files from the CBCT were imported to the planning software, the stone model of the patient was digitally obtained using a laboratory optical scanner and saved as a Standard Triangle Language (STL) file. The optical scan of the cast was registered to the CBCT using the teeth as common landmarks in both images. Merging was performed between bone from CBCT & teeth from the cast without the gingiva at the area of operation. The whole project was then exported as STL. The guide design was made to be tooth and bone supported in which the osteotomies were directed. The design was then saved and converted into STL format for printing the model using 3D printer (Form2 3D printer, Form labs, USA) thus transferring the virtual plan to the operating room. The guide was fit on the teeth (reference point) from above and adapted on bone on the buccal side.

Surgical Procedure

All patients were treated under local or general anesthesia each according to his choice. Articaine 4%, 40.00 mg was used for local anesthesia, hydrochloride and Epinephrine 1:200,000. For general anesthesia vasoconstrictor (Epinephrine 1cm diluted in 200cm saline) was injected in the area of the incision for hemostasis. Access to retromolar area in which the releasing incision was done anteriorly from the vestibule upwards towards the midway of first and second molar area, then the incision was continued in the gingival sulcus in dentulous ridge (over crest of the alveolar ridge, in case of an edentulous area) up to the distal aspect of the third molar area. Distally releasing incision started from the distal most point of the third molar area crossing the external oblique ridge into the buccal mucosa. The bone was exposed at the level of external oblique ridge and lateral aspect of the ramus. The pre-fabricated surgical guide stent for the first group was placed over EOR. Four osteotomies were performed, two vertical and two horizontal)Fig(1.. According to the window of the guide, the osteotomy cuts were done with the same dimensions using the peizosurgical blade according to the planned depth. The harvested bone block was removed by gentle manipulation. The same osteotomy cuts were performed without a surgical guide in the second group, but care was taken to avoid its injury of the inferior alveolar nerve. Then tension free suturing was done to allow secondary healing.

The harvested bone block was split into two thin bone plates, and bone chips were scraped from the inner surfaces of the bone plate. One plate was fixed to the buccal surface of the defect with micro screws, the second plate was crushed into small fragments and mixed with bone chips gained from scrapped medullary surfaces of the separated cortical plates then filling the gap between the bone plate and the defective alveolar ridge.

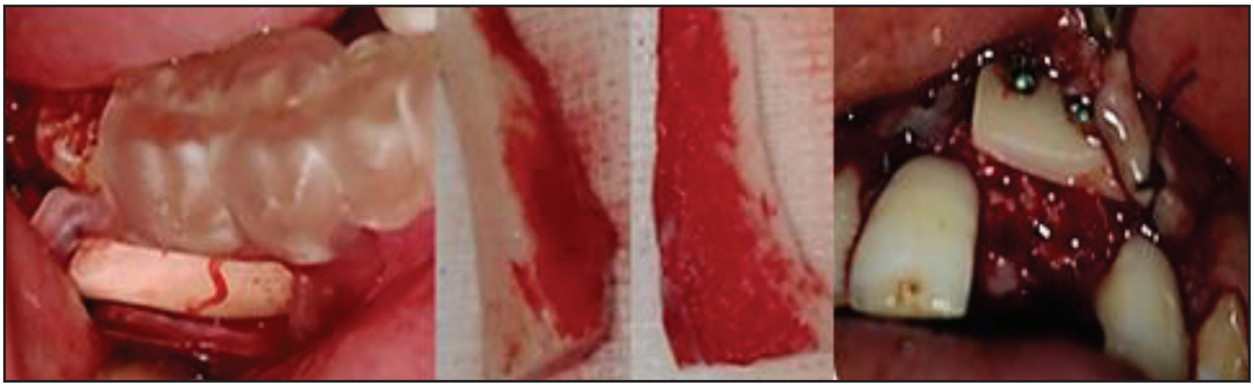

Figure (1) (A, B, C) photographs showing: (A) Surgical bone guide in group A seated on exposed EOR. (B) The outer and inner surfaces of the cortical plates immediately following the split. (C) Fixation of one plate on the buccal side of the defect with micro screws and crushing the other plate, then filling the gap with crushed bone.

Postsurgical phase

All patients were examined for any complications or sensory alterations in the IAN using visual analogue scale (VAS), sharp/blunt discrimination and light touch (LT) tests. Immediate postoperative CBCT scans were taken for all the patients in both groups to measure the study variables within the 1st postoperative week.

Fusion was performed between preoperative, immediate and postoperative CBCT to compare buccolingual/palatal dimensions and to assess differences from virtual plan. Then fusion was performed between immediate and six months postoperative CBCT to determine the amount of bone resorption after augmentation.

Statistical Analysis

Data were represented as means, standard deviations, ranges, and percentages to summarize the demographic postoperative measurement data. The complications or sensory alterations in the IAN and the amount of bone resorption after augmentation in both groups were also analyzed by using paired t-test for normally distributed data and Wilcoxon test for non-parametric data, to compare between groups. Result was considered statistically significant if the p-value was less than 0.05. All statistical calculations were performed by using SPSS software program version 20.0.

RESULT

Twelve patients (8 females and 4 males) were enrolled in this study with alveolar bone defects that were selected for dental implant placement. The mean of patients' age was 24.08±6.6 years. The mean of the preoperative mesiodistal dimensions (MDD) at recipient sites in group A was 19.08±5.1mm, with range between 11.5-26.5mm. The mean of the preoperative MDD in group B was 16.88±2.8mm with range between 12-20 mm.

The dimensions of the alveolar ridge immediately after augmentation was measured by superimposition of preoperative and immediate postoperative CBCT scans at three consecutive points; the first point was at the level of initial alveolar crest, the second point was 3 mm apical to the initial alveolar crest and third point was 6mm apical to the initial alveolar crest. It was noticed that there was a marked increase in the dimensions of the alveolar ridge between the two studied groups. Where, the mean of ridge dimensions after augmentation at these points in group A were 6.95 ± 1.5 mm and in group B 7.07 ± 0.8 mm. No significant difference was detected at the immediate postoperative dimensions of the ridge between the two groups.

The rate of the alveolar bone resorption at six months from augmentation was measured after superimposition of immediate and six months postoperative CBCT scans. The same points were used to measure the changes in the dimension of the alveolar ridge. The results showed that there was no significant difference in the immediate postoperative measures between the three points in group A. While, in group B the difference between first and third point showed statistically significant difference where p value = 0.019. Measurements taken at six months showed that, in both groups there was statistically significant difference between first and second points, where all p values were less than 0.05, and highly significant difference between first and third points, where all *p*-values were less than 0.01, while no significant difference was noticed between second and third points (table 1).

Also, results have demonstrated that the planned dimensions either mesiodistal or vertical showed statistically insignificant difference between the two studied groups where all *p*-values were more than 0.05. The accuracy of cutting regarding mesiodistal dimensions differs significantly between the two studied groups where all *p*- values were less than 0.05 and highly differed regarding the vertical dimensions where all *p*- values were less than 0.01, with the best accuracy among group A compared to group B. The patients at group A had greater amount of bone remaining around the nerve than group B either at the beginning, at the middle or at the end of the osteotomy.

Table (1): *Comparison between the two studied groups according to the rate of bone resorption at recipient site; immediate postoperative CBCT scans compared to six months postoperative after its superimposition on immediate postoperative.*

	Three consecutive points from the crest of the alveolar ridge	0 Month Mean ± SD	0 Month + 6 Months Mean ± SD	Mean difference	Percent difference	p value
Group A	**1st**	6.29 ± 0.7	5.1 ± 1.0	1.19 ± 0.5	18.92%	<0.001**
	2nd	6.98 ± 1.4	6.3 ± 1.2	0.68 ± 0.5	9.74%	0.001**
	3rd	6.85 ± 1.6	6.52 ± 1.3	0.33 ± 0.5	4.82%	0.07
	P value	0.425	0.018*	0.001**	<0.001**	
	P value (1st & 2nd)	0.221	0.024*	0.019*	0.024*	
	P value (1st & 3rd)	0.319	0.009**	<0.001**	0.009**	
	P value (2nd & 3rd)	0.815	0.663	0.097	0.663	
	Mean	6.71 ± 1.2	5.98 ± 1.1	0.73 ± 0.3	10.88%	<0.001**
Group B	**1st**	6.36 ± 0.7	5.28 ± 0.5	1.08 ± 0.5	16.98%	<0.001**
	2nd	7.17 ± 0.9	6.22 ± 0.8	0.95 ± 0.3	13.25%	<0.001**
	3rd	7.53 ± 1.2	6.66 ± 1.1	0.87 ± 0.3	11.55%	0.01*
	P value	0.053	0.008**	0.721	0.296	
	P value (1st & 2nd)	0.096	0.03*	0.61	0.314	
	P value (1st & 3rd)	0.019*	0.002**	0.43	0.128	
	P value (2nd & 3rd)	0.441	0.293	0.777	0.588	
	Mean	7.02 ± 0.9	6.05 ± 0.8	0.97 ± 0.3	13.82%	<0.001**

** Significant Difference (p<0.05), ** Highly Significant Difference (p<0.01), 0 Month (immediate postoperative)*

DISCUSSION

Augmentation of the alveolar ridge defects has been carried out over the years. Still, no single procedure has proved to be better than the other [1]. The teeth, jaws, and oral mucosa are not static objects; they are dynamic objects which undergo changes over the time. The general changes in the dimension of the alveolar ridge after tooth loss show different resorption patterns [15]. Resorption of the alveolar process in the maxilla or mandible is significantly larger at the buccal aspect than at the lingual/palatal aspect of the jaws [16]. This prospective study aims at evaluating the role of computer- assisted autogenous bone graft that was harvested from external oblique ridge at retromolar area for augmentation of the defective alveolar ridge using Khoury technique with or without the use of the surgical guide.

An autogenous bone graft from EOR was considered the favorite donor site for intraoral autogenous bone graft as it provides enough bone quantity, lack of cutaneous scars and could be accomplished in the outpatient operatory without the need for general anesthesia [17]. The augmentation technique used in this study procured grafts at a distance from the alveolar ridge. This combines the benefits of both types of bone (cortical and cancellous) as confirmed by other authors [18-20].

In our study, there were marked increases in the dimensions of the alveolar ridge among studied groups at three consecutive points from the crest of the alveolar ridge immediately after augmentation. While, the rate of bone resorption was noticed more at the crest of the alveolar ridge after six months postoperatively, in which 18.92% in group A and 16.98% in group B. This was in agreement with the findings of other research that revealed a resorption rate in the width of the alveolar process after mandibular ramus grafting, was 18.38% [21].

In the present study one complication was reported in (16.7%) the second group as an impairment of the sensory function of inferior alveolar nerve. Disturbances of sensation were only temporary and then the sensations was gradually regained to normal on reaching the third month and consequent time. This observation corresponded to other reports in the literature illustrating comparable results in which nerve rehabilitation occurred within a duration of 3-5 months after the bone graft that was harvested from the retromolar region [6, 22, 23].

In this study, the computer-assisted osteotomy was used to evaluate the efficacy of computer-assisted template in overcoming these problems in IAN injury during the harvesting procedures. The results revealed that the CAS helped in preoperative planning of the osteotomies sites. In group A, CAS provided a chance for the surgeon to get information about the surgical field as regards to superficial position of the osteotomy lines with ability to maximize and relate the dimensions of the harvestable bone block to bone dimensions necessary for reconstruction of the alveolar defect. This observation is in accordance with other research [24].

CONCLUSION

Computer-guided harvesting procedures is a successful method for augmenting defective alveolar ridges. In which the osteotomy lines are controlled, with the ability to maximize and relate the dimensions of the bone block that is harvested to the dimensions of the bone needed for reconstruction of the alveolar defects.

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RECOMMENDATIONS

Further studies should be conducted using computer assessed surgical guides to determine, precise transfer of the virtual planning to the surgical field that minimizes intraoperative complications to inferior alveolar nerve during harvesting procedures from retromolar area.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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