Original Article

Evaluation of Efficacy of Autogenous Dentine Grafts in Socket Preservation Post-Exodontia Using Bone Densitometric Analysis in Grafted and Non-Grafted Healing Extraction Sockets Following Bilateral Mandibular Third Molar Extractions: A Prospective, Evaluative Study

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Abstract

Background: When a tooth is lost, a general lack of stimulation of the remaining alveolar bone results in a decrease in trabeculae and subsequently, bone density in the post-extraction alveolus. In recent years, numerous bone augmentation techniques employing a range of bone graft materials have been used to reconstruct the deficient vertical and/or, horizontal alveolar ridge dimensions. **Objective**: To evaluate the efficacy of autogenous dentine grafts in socket preservation post-exodontia. **Methods**: This was a split-mouth study design which included 60 subjects, while the bone density was assessed in the test (grafted) and controlled (non-grafted) sites following bilateral mandibular third molar extractions after placement of dentine grafts. Furthermore, bone density was assessed in the both horizontal and vertical planes, while patients were evaluated pre-operatively and then, immediate post-operatively and at the end of 1 week, 1 month, 3 months and 6 months. **Results**: The results obtained in the present study indicated statistically significant differences in terms of the mean bone density values when compared between the test and controlled sites at various levels and at different treatment time points using independent-samples t-test ($p<0.05$). **Conclusion**: The use of autogenous dentine grafts can be considered to be a viable option for socket preservation post-exodontia; however, a careful and meticulous patient selection and appropriate treatment planning appear to be of utmost significance in order to achieve predictable clinical (and surgical) outcomes.

Keywords: Autogenous dentine grafts, Socket preservation, Bone densitometric analysis, Grafted and non-grafted healing extraction sockets, Evaluative study

Introduction

When a tooth is lost and/or, extracted due to any reason, a general lack of stimulation of the remaining alveolar bone results in a decrease in trabeculae and subsequently, the bone density in the post extraction alveolus. This is accompanied by a loss of the width of the buccal alveolar bone along with the height of the residual alveolar bone.[1] The risk of bone loss is even more marked during the first 8 weeks after tooth loss. It is reported that in this process, the bone height decreases by 25% during the first year after tooth loss, with about 4mm loss of the residual alveolar bone height during the first-year post extraction.[2]

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The changes in vascularization are also significant during this period, with intra-bony vascularization shifting to a more centripetal, periosteal vascularization after tooth loss or extraction.[3] Furthermore, impacted mandibular third molar extractions, whether prophylactic or therapeutic, are very common in the practice of oral and maxillofacial surgery with the frequency of these impactions lying between 66-77% in the general population.[4] Surgical removal of impacted third molar teeth often requires reflection of a full-thickness mucoperiosteal flap followed by bone removal via an osteotomy procedure. This surgical man oeuvre often leads to extensive tissue manipulation and/or trauma at tissue level with the extent of bone removal dependent on the placement of the tooth within the jawbone, its angulation and the anatomy of the impacted tooth indicated for extraction.[5]

It has been shown that surgical removal of impacted mandibular third molar teeth and related osteotomy procedures often result in the creation of significant intra- bony defects near the distal aspect of the second molars.[5] To combat this, in recent years, numerous bone augmentation techniques employing a range of bone graft materials have been used to reconstruct the deficient vertical and/or, horizontal alveolar ridge dimensions.[6] In a similar context, although, the use of bone substitutes including the allogenic, alloplastic and/or, xenogeneic bone filler materials with or without barrier membranes is widely practiced, autogenous bone as bone graft material is still considered the gold standard treatment modality for bone regeneration, as it is fulfills all the criteria of a successful bone regeneration process which includes; osteogenesis, Oste induction and osteoconduction that occur during the process of bone healing.[7,8]

The use of autogenous bone as bone graft material does not, however, come without limitations. The prominent disadvantages are the need for the creation of a second surgical site for the obtainment of graft material, unpredictable resorption of grafted bone, risk of donor site complications, and limited bone availability from conventional bone graft harvesting techniques.[9] In a similar context, while recent advances in tissue engineering and stem cell sciences have led to the development of several newer techniques for achieving successful bone regeneration, autogenous dentine has been an important topic of study due to its potential use as an ideal bone substitute material because of the identical physical and chemical characteristics.



Figure 1: Pre-operative orthopantomography (OPG) of a patient revealing bilateral mandibular third molar (mesioangular impactions).

These characteristics include density, roughness and homogeneity matching with that of bone, making it the most appropriate and biocompatible bone graft material. [10,11] Currently, all extracted teeth are considered as a clinical and biomedical waste and are discarded; after getting specific treatment (cleaning, grinding, demineralizing and sterilising). They can serve as potential graft material to fill alveolar bone defects if used in the same patient. [12,13]

The aim of the present study was to evaluate the efficacy of autogenous dentine grafts in socket preservation post-exodontia, achieved by assessing bone density and indirectly, the bone regeneration process in the grafted and non-grafted healing extraction sockets following bilateral mandibular third molar extractions in a given set of patients.

Methods

Study Population

For the present prospective study, a total of 60 subjects in the 18-40 age group who visited the Outpatient Department (OPD) presenting with an indication for bilateral mandibular third molar extractions were selected; this accounted for a total of 120 extraction sites in 60 subjects, one on each side. Only normal, healthy adults in the defined 18-40 age group presenting with indication of extraction of non-infected, bilateral mandibular third molar teeth were included, provided the subjects were otherwise systemically healthy, had adequate oral hygiene and were willing to participate in the study. Patients who presented with acute infections and/or grossly carious teeth, have known systemic diseases such as diabetes mellitus and cardiovascular diseases, were immunocompromised and/or on drugs such as corticosteroids and bisphosphonates (which are known to affect the outcomes of the grafting procedures) were excluded. Furthermore, subjects who expressed an unwillingness to follow the instructions provided and maintain good oral hygiene, as well as those with a history of smoking, alcohol consumption, pregnant and lactating females were excluded from the study.

Ethical Considerations

The selected participants were duly informed about the study and the need for compliance with the instructions provided and follow-ups required during the course of the study. Written, informed consent was obtained from all study participants prior to their inclusion in the study, while permission to conduct the study was obtained from the Institutional Ethics Committee (IEC) via letter approval no. PMNMDCH/ IEC/2047/26 before the commencement of the study. The study strictly adhered to Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines laid for cohort studies to ensure completeness, transparency and methodological rigor in reporting the findings

Study Protocol

This was a split-mouth study, wherein densitometric analysis was performed on 60 subjects presenting with indication of bilateral mandibular third molar extractions pre- and post-exodontia with or without the placement of autogenous dentine grafts. A detailed case history was recorded for all subjects followed by a conventional oral examination (COE) and relevant diagnostic procedures in the form

of serological and radiographic investigations, which included the procurement of intraoral periapical radiographs (IOPARs) in the region of interest and orthopantomographs (OPGs) [Figure 1].

Surgical procedure: Before the surgical procedure, all patients were instructed to use a 2% chlorhexidine mouthrinse. After achieving adequate local anaesthesia using 2% lignocaine with 1:200,000 adrenaline, atraumatic extractions of bilateral mandibular third molar teeth were performed, avoiding damage to the surrounding alveolar bone. After extraction of the tooth on the test side, enamel, discolored dentine, cementum and remnants of periodontal ligament were reduced using a tungsten carbide bur. The cleaned tooth including the crown and root dentine was placed into a sterile grinding chamber of a high-speed grinder operating at a power setting of 150W and at a speed of >700 revolutions per minute (rpm) to grind the dentine into particles of <1200µm. After this, the particles were separated through a sieve to filter particles in a size range of 500-1200µm. To achieve graft sterilisation, these particles were immersed in 1N lactic acid for a period of 15-20 minutes, which also partially decalcified them. Later, the graft particles were thoroughly washed using normal saline for a period of 60 seconds to remove any traces of lactic acid. The material was placed in the test socket [Figure a], and primary wound closure was accomplished using non-absorbable, braided black silk 3-0 sutures [Figure 2b]. On the control side, the alveolus was left to heal in the conventional way by the formation of a blood coagulate following the extraction procedure. This was followed by immediate post-operative radiographs taken after placing the graft material, and the bone density was assessed. The participants were subsequently recalled after 1 week, 1 month, 3 months and 6 months post-procedure for comparative follow-ups. Clinical and radiographic bone density assessment [Figure 3a-d] were done in both the test and control sites.



Figure 2: a) Upper- Placement of autogenous dentine grafts in the post-extraction alveolus; and b) Lower- Primary wound closure accomplished using non-absorbable, braided black silk 3-0 sutures

Bone Densitometric Analysis: Bone densitometric analysis was performed using KODAK Dental Imaging Software version 6.12.11.0 (Carestream Dental, Rochester, New York, USA), specialized software inbuilt in the KODAK 8000C Digital Panoramic and Cephalometric Imaging System. The specific version of the KODAK Dental Imaging Software version 6.12.11.0 includes specialized tools for the assessment of bone, specifically featuring a bone densitometric analysis tool that can be used to evaluate bone density in defined areas, providing numerical variables for the assessed bone density in the region of interest.

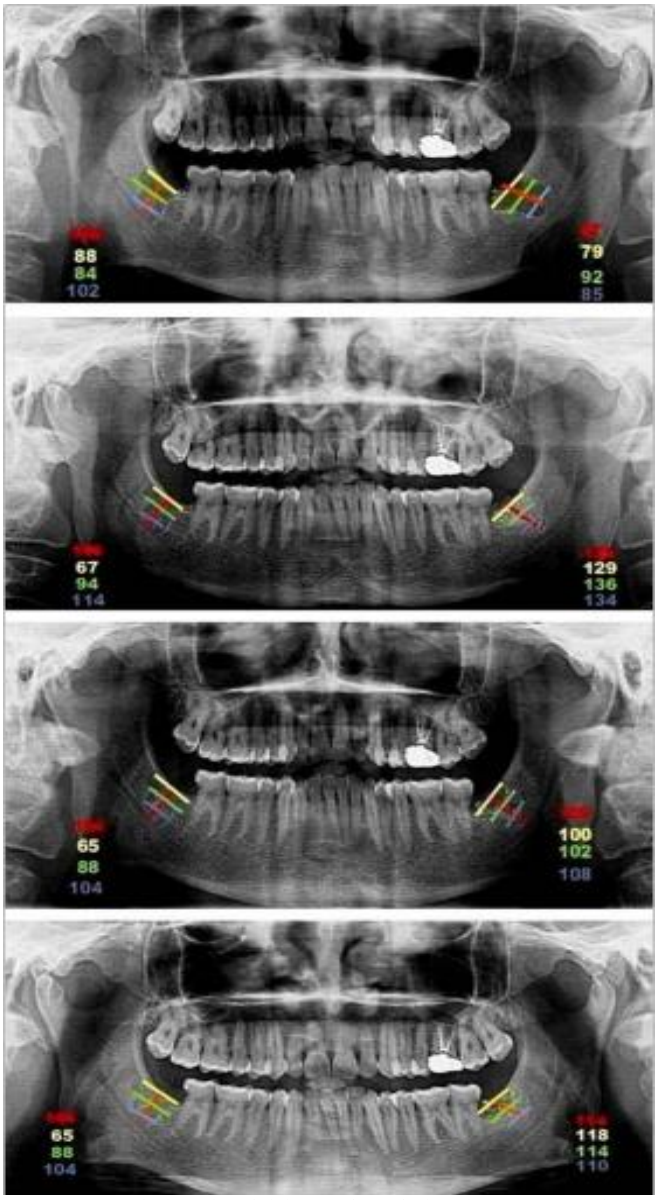


Figure 3a-d: Bone densitometric analysis in test and control sites using KODAK Dental Imaging Software 6.12.11.0 inbuilt in KODAK 8000C Digital Panoramic and Cephalometric Imaging System: From top to bottom- a) Pre-operatively; b) Immediate post-operatively; c) At the end of 1 week; and d) At 6 months post-procedural follow-up visit of patient.

The software is designed to quantify, analyse, and store the digital radiographic images and is frequently used for measuring alveolar bone loss and/or bone quality of the residual alveolar bone in both two-dimensional Panoramic radiographs [also, orthopantomographs (OPGs)] as well as three-dimensional contexts, such as Cone Beam Computed Tomography. The specialized inbuilt software features a density icon group that allows users to draw a section line on an image to analyse the relative density of the bone tissue along that line. The radiographic images were first viewed on a flat screen, Dell Thin Film Transistor Liquid Crystal Display (Dell TFT-LCD) monitor. The images, which were initially digitised in the Digital Imaging and Communications in Medicine (DICOM) file format, were subsequently converted into the Joint Photo- graphic Experts Group (JPEG) file format and were viewed at a resolution of 2906x2304 pixels with 24-bit greyscale.

Parameters assessed: The specific pre- and post-operative variables assessed included:

Pre-operative variables: At the first visit, the variables assessed included the patients' age and sex, and their medical and dental histories, along with the position of the tooth to be extracted, which was assessed using IOPARs in the region of interest and OPGs. Furthermore, mouth opening was assessed using the digital vernier calipers by measuring the distance between the upper and lower central incisors to obtain baseline data for future comparisons to relate post-operative trismus (reduction in mouth opening) during follow-up visits.

Post-operative variables: Immediate post-operative radiographs, including IOPARs in the region of interest and OPGs, were taken after placing the graft material, while bone density was reassessed. This was repeated at all follow-up visits after the surgical procedure. Furthermore, the level of inflammation was evaluated by measuring facial patterns for the assessment of post-operative facial swelling a week and a month after the surgical procedure. This was accompanied by an assessment of post-operative pain, which was rated on the Visual Analogue Scale (VAS) scoring criteria in the range of 1-10, with 1 representing minimal pain and 10 representing maximum pain, in addition to measurements of mouth opening using digital vernier calipers at all follow-up visits.

Sample size estimation

Hypothesis testing for two means (equal variances):

Standard Deviation (S.D.) in group I: S1=11.453;

Standard Deviation in group II: S2=9.231 Mean difference between group I and group II: =5.7554

Effect size=0.5565

Alpha (α) Error =5%

Power =85%

Sided=2;

Number needed (n)=120 (60 in each group).

Formula used to calculate sample size:

$$n = \frac{2S^2(z_{1-\alpha} + z_{1-\beta})^2}{d^2}$$

Where, ZI-α=Z-value for α level (1.96 at 5% α error or 95% confidence)

Z1-β=Z-value for β level (1.0370 at 15% β error or 85% power)

d=Margin of error=5.7554

S=Pooled S.D.=(S1+S2)/2

Total sample size=120 (60 in each group including the test and control sites).

Statistical analysis used:

The data were analysed using the Statistical Package for Social Sciences (SPSS) version 22.0 (SPSS Inc., IBM Corporation, Armonk, New York, United States) statistical software.

Mean and standard deviations were calculated for the quantitative variables, while frequency and proportions were used to represent the categorical variables. Chi-squared test (χ^2 test) was used to analyse the relationship between the independent variables, while Friedman's ANOVA and independent- samples t-test were used to analyse the continuous variables. *P*-value <0.05 was considered to be statistically significant.

Results

Table 1 presents the age, gender. and site-wise distribution of the sample, wherein 60 subjects aged 18-40 years were included in the present study, with a mean age calculated to be around 30.57±6.06 years. In total, 25 males (41.7%) and 35 females (58.3%) were included in the study.

Table 1: Age, gender and site-wise distribution of the sample

Variables	Percentages
Age in years	
Minimum/Maximum	**18/39**
Mean±S.D.	**30.57±6.06**
Gender	
Male	**25 (41.7)**
Female	**35 (58.3)**
Site	
38	**60 (50.0)**
48	**60 (50.0)**
Total	**120 (100.0)**

Table 2 presents the pain scores as assessed on the Visual Analogue Scale (VAS) at different treatment time points using Friedman's ANOVA. As the effect of local anaesthesia diminished, pain appeared, but this had worn off by the end of 1st week, with 57 (95.0%) patients presenting with a pain score of 0 and 3 (5.0%) patients presenting with a pain score of 1 at the end of 1st week (*p*=0.0001). Similarly, Table 3 shows the data related to swelling and signs of delayed wound healing observed in patients at different treatment time points using Friedman's ANOVA, wherein 19 (31.7%) patients presented with swelling at the end of 1st week as against signs of delayed wound healing, which were observed in only 9 of the 60 (15.0%) patients included in the study. At 1 month follow-up visit, none of the patients revealed signs of swelling and/or delayed wound healing, showing a 100% recovery rate, with the results being statistically highly significant (*p*=0.0001).

Table 2: Pain scores as per Visual Analogue Scale (VAS) scoring criteria at different treatment time points using Friedman's ANOVA

Pain score (s)	Pre-op n	%	Post-op n	%	1 week n	%	1 month n	%	3 months n	%	6 months n	%	p-value
0	0	0.0	0	0.0	57	95.0	60	100.0	57	95.0	60	100.0	0.0001**
1	0	0.0	0	0.0	3	5.0	0	0.0	3	5.0	0	0.0	
2	4	6.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	
3	16	26.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	
4	21	35.0	1	1.7	0	0.0	0	0.0	0	0.0	0	0.0	
5	13	21.7	7	11.7	0	0.0	0	0.0	0	0.0	0	0.0	
6	5	8.3	28	46.7	0	0.0	0	0.0	0	0.0	0	0.0	
7	1	1.7	21	35.0	0	0.0	0	0.0	0	0.0	0	0.0	
8	0	0.0	3	5.0	0	0.0	0	0.0	0	0.0	0	0.0	
Total	60	100.0	60	100.0	60	100.0	60	100.0	60	100.0	60	100.0	

**p-value<0.001- statistically highly significant

Table 3: Swelling and signs of delayed wound healing at different treatment time points using Friedman's ANOVA

Variable (s)	Present n	%	Absent n	%	p-value
Swelling					
Immediate post-op 1 week	1	1.7	59	98.3	0.0001**
1 month	19	31.7	41	68.3	
Delayed wound healing	0	0.0	60	100.0	
1 week	9	15.0	51	85.0	0.0001**
1 month	0	0.0	60	100.0	

**p-value<0.001- statistically highly significant

Table 4: Mouth opening (in mm) at different treatment time points using Friedman's ANOVA

Variable(s)	n	Minimum	Maximum	Mean	S.D.	p-value
Pre-op	60	25.0	42.0	37.30	2.644	0.0001**
1 week	60	32.0	42.0	37.78	1.814	
1 month	60	32.0	42.0	38.32	1.408	
3 months	60	32.0	42.0	38.53	1.478	
6 months	60	32.0	42.0	38.67	1.591	

**p-value<0.001- statistically highly significant

Table 5: Bone density in test sites (grafted sockets) at different levels and at different treatment time points using Friedman's ANOVA

Variable (s)	n	Mean	S.D.	p-value
At crestal level in the horizontal, axial, transaxial or, transverse plane				
Pre-op	60	97.23	13.636	0.000**
Immediate post-op	60	123.60	13.797	
1 week	60	94.28	15.228	
1 month	60	116.82	7.901	
3 months	60	128.40	9.130	
6 months	60	141.20	11.453	
At mid-level in the horizontal, axial, transaxial or, transverse plane				
Pre-op	60	97.35	12.749	0.000**
Immediate post-op	60	123.77	12.903	
1 week	60	94.40	15.044	
1 month	60	115.75	10.393	
3 months	60	129.02	10.169	
6 months	60	142.38	12.318	
At apical level in the horizontal, axial, transaxial or, transverse plane				
Pre-op	60	95.32	13.452	0.0001**
Immediate post-op	60	122.48	12.172	
1 week	60	94.15	14.451	
1 month	60	113.85	11.576	
3 months	60	126.80	9.697	
6 months	60	140.30	12.223	0.0001**
In vertical plane				
Pre-op	60	98.35	12.517	
Immediate post-op	60	124.47	11.435	
1 week	60	95.90	14.759	
1 month	60	115.78	13.268	
3 months	60	129.72	10.026	
6 months	60	144.97	12.236	

***p*-value<0.001- statistically highly significant

Table 6: Bone density in controlled sites (non-grafted sockets) at different levels and at different treatment time points using Friedman's ANOVA

Variable(s)	n	S.D	Mean	P-value
At crestal level in the horizontal, axial, transaxial or transverse plane				
Preop	60	97.28	12.875	0.0001**
1 week	60	92.29	13.243	
1 month	60	111.70	7.413	
3 months	60	121.87	8.621	
6 months	60	130.90	9.231	
At mid level in the horizontal, axial, transaxial or transverse plane				
Preop	60	96.10	12.136	0.0001**
1 week	60	92.73	12.946	
1 month	60	110.57	6.667	
3 months	60	120.50	8.305	
6 months	60	130.9	9.705	
At apical level in the horizontal, axial, transaxial or transverse plane				
Preop	60	95.38	11.528	0.0001**
1 week	60	91.35	13.297	
1 month	60	108.67	7.387	
3 months	60	118.47	7.725	
6 months	60	128.32	8.992	
In vertical				
Preop	60	96.17	10.826	0.0001**
1 week	60	91.83	12.904	
1 month	60	109.22	7.230	
3 months	60	117.87	7.615	
6 months	60	128.52	8.858	

***p*-value<0.001- statistically highly significant

Table 4 presents the data related to the extent of mouth opening (in mm) observed in patients at different treatment time points using Friedman's ANOVA with statistically significant (p=0.0001) findings. Again, Table 5

presents the bone density as evaluated in test sites (grafted sockets) at different levels, including in the horizontal and vertical planes, and at different treatment time points using Friedman's ANOVA, while Table 6 presents similar values in the controlled sites (non-grafted sockets) at different levels and at different treatment time points using Friedman's ANOVA, with the mean differences in the measured bone density being of high statistical significance (p-value<0.001) in either case when assessed at the various levels and treatment time points.

Finally, Table 7 presents the comparison of bone density as assessed in the test (grafted sockets) and controlled (non-grafted sockets) sites at different levels and treatment time points using the independent-samples t-test, wherein the results were found to be statistically significant in terms of bone density when compared between the test and controlled sites at the mid-level in the horizontal plane at 1 month (p=0.046), at the apical level in the horizontal plane at 6 month (p=0.051), and in the vertical plane at 1 month (p=0.029) and 3 months (p=0.028) follow-up visits.

Table 7: Comparison of bone density in test (grafted sockets) and controlled (non-grafted sockets) sites at different levels and at different treatment time points using independent samples t-test

Variable (s)	Group Statistics	n	Mean	S.D.	p-value
At crestal level in the horizontal, axial, transaxial or, transverse plane					
Pre-op	Test site	60	97.23	13.636	0.688
1 week	Controlled site	60	97.28	12.875	0.247
1 month	Test site	60	94.28	15.228	0.583
3 months	Controlled site	60	92.90	13.243	0.624
6 months	Test site	60	116.82	7.901	0.152
	Controlled site	60	111.70	7.413	
	Test site	60	128.40	9.130	
	Controlled site	60	121.87	8.621	
	Test site	60	141.20	11.453	
	Controlled site	60	130.90	9.231	
At mid-level in the horizontal, axial, transaxial or, transverse plane					
Pre-op	Test site	60	97.35	12.749	0.566
1 week	Controlled site	60	96.10	12.136	0.146
1 month	Test site	60	94.40	15.044	0.046*
3 months	Controlled site	60	92.73	12.946	0.159
6 months	Test site	60	115.75	10.393	0.195
	Controlled site	60	110.57	6.667	
	Test site	60	129.02	10.169	
	Controlled site	60	120.50	8.305	
	Test site	60	142.38	12.318	
	Controlled site	60	130.90	9.704	
At apical level in the horizontal, axial, transaxial or, transverse plane					
Pre-op	Test site	60	95.32	13.452	0.208
1 week	Controlled site	60	95.38	11.528	0.415
1 month	Test site	60	94.15	14.451	0.069
3 months	Controlled site	60	91.35	13.297	0.098
6 months	Test site	60	113.85	11.576	0.051*
	Controlled site	60	108.67	7.387	
	Test site	60	126.80	9.697	
	Controlled site	60	118.47	7.725	
	Test site	60	140.30	12.223	
	Controlled site	60	128.32	8.992	
In vertical plane					
Pre-op	Test site	60	98.35	12.517	0.320
1 week	Controlled site	60	96.17	10.826	0.323
1 month	Test site	60	95.90	14.759	0.029*
3 months	Controlled site	60	91.83	12.904	0.028*
6 months	Test site	60	115.78	13.268	0.079
	Controlled site	60	109.22	7.230	
	Test site	60	129.72	10.026	
	Controlled site	60	117.87	7.615	
	Test site	60	144.97	12.236	
	Controlled site	60	128.52	8.858	

Discussion

Tooth extraction and subsequent healing of the extraction socket commonly result in the creation of osseous defects in the residual alveolar ridge including reduced height and width irrespective of the cause of extraction.[14] During the natural course of healing in the post-extraction phase, a general reduction in alveolar bone width of about 2.6-mid-level and height of about 0.4-3.9 mm are usually observed, as reported in the studies conducted by Pinho *et al*.[2] and Ten Heggeler *et al*.[3] This bone resorption, subsequently results in decreased ridge volume with deforming ridge contours, eventually resulting in narrowing and atrophy of the native alveolar ridge, relocating the ridge to a more lingual position. The process of ridge remodeling is further complicated if the buccal bone wall is completely lost as a result of faulty technique used during extraction or in the natural course of the inflammatory process that ensues post-exodontia.[1,14] However, it is possible to minimize these complications by carrying out ridge preservation post extractions using grafts in healing extraction sockets, with or without the use of barrier membranes.

In a similar context, three ideal properties which are always sought in graft materials include: osteogenesis, which involves the induction of cells within the graft material to promote bone regeneration, osteoinduction which promotes the recruitment of bone-forming cells such as the undifferentiated cells and pre- osteoblasts and the formation of bone from these cells. Furthermore, osteoconduction, which promotes the recruitment of bone-forming cells such as the undifferentiated cells and pre-osteoblasts is essential for natural bone regeneration process.[15,16] Different types of bone substitutes Aare used for this purpose, which primarily include demineralized freeze-dried bone allograft (DFDBA) and hydroxyapatite. In a similar context, the advantages of using autogenous tooth bone grafts include their unique property to initiate osteogenesis, osteoinduction and osteoconduction, while also not inducing potential immunogenic reactions.[17,18] While extracted teeth have traditionally been regarded as biomedical waste, they are currently being researched to act as the potential source of autogenous tooth bone graft materials. The first autogenous tooth bone graft (AutoBT) was developed in 2008 which has been primarily used for guided bone regeneration (GBR) to supplement dental implants, with its histological outcomes similar to the autogenous bone grafts.[9] It was observed that autogenous tooth bone graft materials led to the formation of new bone in 46-87% of the area of interest during the first 3-6 months period; this was confirmed in histological studies wherein excellent bone healing was observed due to the osteoconduction effect, revealing osteoid tissue in the reabsorbed matrix with the well-vascularized, dense fibrous, connective tissue present adjacent to the graft material directly fusing with the newly formed bone.[14]

A landmark observation in this regard was made in the study conducted by Al-Asfour et *al*.,[19] wherein the authors tried to evaluate healing pattern of xenogenic demineralized dentine onlay grafts as compared with autogenous bone grafts when implanted to a rabbit tibia, where the authors concluded that the former showed nearly identical resorption characteristics including resorption rate and patterns, as shown by autogenous bone onlay grafts. Furthermore, autogenous tooth bone grafts can be used in particulate or block graft forms, while studies have indicated no significant differences in the amount of volumetric reduction between the particulate bone and block bone grafts.[20,21] In the present study, bone density was assessed before and immediately after the conduct of extractions, while the process of osseous regeneration was evaluated following the placement of graft at 1 week, 1 month, 3 months and 6 months post-procedural follow-up visits. Also, radiographic images stored in JPEG graphic file format were used for assessment of bone density in present study, similar to the methodology used in the study conducted by Dhuvad and Mehta.[21]] In total, a group of 60 subjects, including 25 males (41.7%) and 35 females (8.3%%) in an age range of 18-40 years were included in the present study with the mean age of subjects calculated to be 3057±6.06 years. The results of the present study revealed that 57 (95.0%) patients presenting with a pain score of 0, and 3 (5.0%) patients presented with a pain score of 1 by the end of 1st week (p=0.0001), which later diminished to a pain score of 0 as time progressed, in close accordance with the findings of the study conducted by Sánchez-Labrador *et al*.,[4] who observed that the pain scores were found to be similar in both the test and control groups, with a mean score of 5.33 at the time of surgery, which later fell to 4.33 vs. 4.27 on the 3rd day, and 1.40 vs. 1.33 on the 7th day after surgery.

The authors also observed that nearly complete mouth opening was achieved in one week, while mouth opening restored to normal in around one-month post-procedure which was in close agreement with the findings of the present study. Jeong *et al*.[22] reported that only 5 patients (9. 1%) out of a series of 51 presented with infection after autogenous tooth bone graft placement that was initially managed with the appropriate antibiotic therapy. However, 2 out of 5 patients, eventually, required removal of the graft, leading the authors to conclude that autogenous tooth bone graft materials were appropriate for use in maxillary sinus augmentation procedures. In the present study, 19 (31.7%) patients presented with swelling, as against the signs of delayed wound healing, which were observed in 9 out of 60 (15.0%) patients included in the study by the end of 1st week. At 1 month follow-up, none of the patients presented with either signs of swelling or delayed wound healing, which was found to be in close accordance with the results obtained in the study conducted by Dhuvad and Mehta.[21]

Wound dehiscence has been reported to be one of the most common complications associated with grafts. In a similar context, Lee *et al*.[16] observed wound dehiscence in 1 out of the 9 patients in whom vertical and horizontal ridge augmentation was performed using powder-or block-type autogenous tooth bone graft material before implant placement, leading the authors to conclude in favour of the same during grafting procedures. Kim *et al*.[12] similarly concluded that autogenous tooth bone graft materials have identical physicochemical characteristics similar to autogenous bone grafts while reporting wound dehiscence in 1 out of the 12 patients included in the study in whom grafts were used. Both studies managed the patients conservatively with antiseptic dressings using chlorhexidine and obtained acceptable results with no significant loss of the graft material. In the systematic review conducted by Ramanauskaite *et al*.,[7] to evaluate the currently existing clinical evidence on the efficacy of autogenous tooth bone graft materials for reconstruction of alveolar ridge deficiencies, the authors pointed out the potential autogenous tooth bone graft materials should possess for the reconstruction of alveolar ridge deficiencies. In the present study, all grafted sites were observed post-operatively for wound dehiscence and movement of the graft from the grafted socket, while wound healing was found to be satisfactory with no evidence of either dehiscence or graft movement by the end of 1st week, achieving a 100% success rate.

Furthermore, in the present study, OPGs taken immediately after placement of dentine grafts revealed radiopaque particles completely filling the entire socket, surrounded by a sharp radiopaque line representing lamina dura, with the mean density of bone measured as 123.60±13.797, 123.77±12.903, 122.48±12.172 and 124.47±11.435 at the crestal, mid apical, apical levels in the horizontal plane and vertical plane respectively.

The findings of the study revealed a sharp decline in the measured bone density values at all levels in both the horizontal and vertical planes, indicating towards the resorption of graft material when assessed by the end of 1st week post-operatively, while the values started increasing afterwards with the mean differences calculated in the measured bone density values carrying high statistical significance ($p<0.001$). Also, the lamina dura of sockets disappeared completely due to bone remodeling which was similar to the observations made in the study conducted by Duvid and Mehta.[21] Similar findings were also observed in the study conducted by Kim *et al.* [2] wherein the anautogenous tooth bone graft material showed gradual resorption in the 1st week while absorption of the demineralized granules was observed on sequential radiographic findings. At 1 month, 3-month and 6-month follow-ups, the sockets were filled with uniform radio dense bone-like tissue. Vohra A. [23] observed that bone density values were higher in grafted extraction sockets than in non-grafted sockets. Similar observations were made in the studies conducted by Khalid *et al.* [24] and Panday *et al.* [25]

In the present study as well, upon comparison of the bone density values as assessed in the test (grafted sockets) and controlled (non-grafted sockets) sites at different levels and treatment time points, the results were statistically significant at various levels and time points during patient follow-up visits, which is in close agreement with the findings of the previously mentioned studies. Among the variety of available bone graft materials, selecting the most suitable one poses a significant challenge. The choice of graft material must be dictated by the extent of the bone defect created and the anticipated procedural complexities. This, in turn, depends on a careful and meticulous patient selection, and appropriate treatment planning which are of utmost significance to achieve predictable clinical and surgical outcomes. Autogenous tooth bone graft materials are highly promising alternative possessing potential advantages similar to autogenous bone graft materials owing to their similar composition to bone, and they can be exceedingly useful in a multitude of clinical situations. While this approach can address patients' hesitation regarding the use of all- and/or Xeno -grafts, autogenous tooth bone graft materials provide greater biocompatibility, eliminate the possibility of antigenic reaction(s), and are cost-effective alternative to commercially available bone graft materials.

Limitations of the Present Study and Future Research Directions

The observations made in the present study were based on a preliminary investigation which mandates further randomized controlled clinical trials with larger sample sizes, adopting stricter clinical and radiographic criteria. Additionally, a tissue-level assessment of the newly formed bone tissue is required to monitor soft tissue dynamics and hard tissue changes to reach valid conclusions. While the software used in the present study provides valuable bone densitometric analysis data, it has defined limitations in assessing the cancellous bone compared to the more advanced 3-D imaging-based software. The software, however, enables the analysis of the attenuated x-ray beam density, which can indicate bone quality. Future studies should utilize recent and more innovative, imaging technologies and methods for assessing bone mineral density, including radiographic absorptiometry, dual- and single-energy X-ray absorptiometry, and quantitative computed tomography, as this would further aid in quantifying bone density values on a direct basis, unlike the methodology used in the present study.

Conclusion

The observations made in the present study indicated that the immediate socket preservation technique using autogenous dentine grafts resulted in adequate bone fill while minimizing residual alveolar bone (ridge) resorption in terms of both socket width and height, both clinically and radiographically. Based on the findings obtained, it was concluded that the use of autogenous dentine grafts can be considered as a viable option for socket preservation post-extraction. However, careful and meticulous patient selection, as well as appropriate treatment planning are of utmost significance in order to achieve predictable clinical and surgical outcomes.

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