Evaluation of Implant Stability Following Sinus Augmentation Utilizing Bovine Bone Mixed with Platelet-Rich Fibrin

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Abstract

Background: Lateral sinus augmentation and simultaneous insertion of dental implants is a highly predictable procedure and associated with high rate of implants success.

Aims: To evaluate implant stability changes following maxillary sinus augmentation utilizing deproteinized bovine bone alone or mixed with platelet-rich fibrin.

Materials and Methods: A total of 34 lateral sinus augmentation procedures were performed and 50 dental implants simultaneously installed. The lateral sinus augmentation cases were allocated randomly into 3 groups: Group A comprised 13 procedures and 21 dental implants utilizing solely deproteinized bovine bone. Group B involved 10 cases and 16 dental implants using deproteinized bovine bone mixed with leukocyte and platelet-rich fibrin. Group C included 11 operations and 13 dental implants employing deproteinized bovine bone mixed with advanced platelet-rich fibrin. Resonance frequency analysis test was performed immediately after implant installation and 24 weeks postoperatively for the measurement of the implant stability.

Results: Implant stability quotient values increased significantly for all study groups 24 weeks after dental implants installation (P= 0.001). The implant stability quotient at T1 (day of implant installation) was 56.93 ±12.01 for group A, 58.34 ±12.82 for group B, and 61.35 ±8.47 for group C. The implant stability quotient at T2 (24 weeks after implant insertion) was 69.17 ±5.10, 69.43 ±5.32, and 68.50 ±7.44, respectively.

Conclusion: The addition of leukocyte and platelet-rich fibrin or advanced platelet-rich fibrin to the bovine bone for sinus floor augmentation did not increased the implant stability quotient value in comparison to the bovine bone alone.

Key Words: *bovine bone, implant stability quotient, maxillary sinus augmentation, platelet-rich fibrin.*

Introduction

Bone remodelling after tooth extraction and maxillary sinus pneumatization often create a clinical challenge for dental implant (DI) placement in the posterior maxilla [(1,2)]. Several surgical approaches have been adopted to increase bone height in the posterior maxillary region for the insertion of DI. Two main techniques were reported for maxillary sinus augmentation; the crestal and lateral approaches [(3)].

Maxillary sinus augmentation through lateral approach (LSA) with concomitant insertion of DI is highly predictable procedure for gaining bone volume in atrophic posterior maxilla and associated with high rate of implants success [(4,5)].

Different types of biomaterials have been used for LSA including autograft, allograft, xenograft, alloplastic, and growth factors [(6,7)]. The clinical suitability of deproteinized bovine bone (DBB) for maxillary sinus augmentation has already been proofed by many studies

[8,9]. Biomaterials with osteoinductive properties, such as platelet-rich fibrin (PRF), which are rich in growth factors were introduced as additional or replacement materials in bone augmentation procedures, aiming to stimulate angiogenesis, enhance new bone formation, improve graft maturation and recovery period [10,11].

One of the most important criteria for implant success is osseointegration. Dental implant stability is an indirect indication of osseointegration, it is a measure of the anchorage quality of an implant in the alveolar bone. Implant stability can be defined as the combination of both primary (mechanical) and secondary (biological) stability [12,13].

Several methods are used for the measurement of implant stability. Resonance frequency analysis (RFA) devices are claimed to be more objective and superior to other methods in measurement of implant stability [13,14]. It provides the clinician with valuable information about the present state of bone-implant interface at various times. Furthermore, it used as a guide for timing of implant loading [15,16].

The objective of the present study was to monitor the changes in DI stability after LSA with simultaneous placement of DI utilizing demineralized bovine bone (DBB) alone or mixed either with leukocyte and platelet-rich fibrin (L-PRF) or with advanced-PRF (A-PRF) as a grafting material during the first six months of healing.

Materials and Methods

Study sample

This randomized prospective clinical study was conducted at the Dental Implant Unit/Department of Oral and Maxillofacial Surgery/College of Dentistry/ University of Baghdad, from January 2019 to August 2020. Twenty-five patients (15 females and 10 males), with a mean age of 51.5 years (ranged 25-72 years). A total of 34 cases with atrophic posterior maxilla who met the eligibility criteria and were suitable candidates for this research.

The LSA cases were randomly allocated into three study groups according to the type of the graft material which was inserted in the created subantral space: Group A comprised 13 procedures and 21 DI, utilizing solely deproteinized bovine bone (DBB) with particle sizes 0.5-1 mm (BEGO OSS, **mebios GmbH,** Germany), group B involved 10 operations and 16 DI, using DBB mixed with L-PRF, and group C included 11 LSA and 13 DI, employing DBB mixed with A-PRF.

Randomization was performed by drawing lots to distribute the grafting materials according to the study groups. The protocol of the study was approved by the Ethical Committee of the College of Dentistry/ University of Baghdad (No. 035118). All patients were informed about the nature of the study and they signed a written consent form for their participation in this study.

Patients were selected according to the eligibility criteria: Healthy individuals without any systemic disease/local pathological lesion at the sinus zone, patients age ≥ 18 years, residual bone height (RBH) ≥ 3 ≤ 6 mm with residual bone width (RBW) ≥ 5mm, and healed implant insertion site at least 6 months after tooth extraction.

Radiological examination

Panoramic radiograph was obtained preoperatively for preliminary evaluation of the residual alveolar ridge. Preoperative CBCT scan was recommended when the candidates were selected for sinus augmentation to provides more informative preoperative assessment of the RBH, RBW, and maxillary sinus anatomy.

Surgical procedure:

One hour prior to the commencement of the surgical procedure, the patient received one capsule of Cefixime 400 mg orally and gargled with 0.2% chlorhexidine mouth rinse for 2 minutes. All surgical procedures were accomplished by an experienced surgeon with this sort of operations. Surgeries were performed under local anesthesia using lidocaine 2% with adrenaline 1:80,000 (Septodont, France). Three-sided flap was performed, followed by reflection of a full thickness mucoperiosteal flap to expose the lateral wall of the maxillary sinus. A lateral window approach was accomplished using conventional drilling technique with round diamond bur.

Gentle elevation of the Schneiderian membrane (SM) using Frios Sinus Set elevators (Dentsply Friadent, Germany). Preparation of implant insertion sites using NucleOss T6 surgical kit (Turkey). Undersized drilling protocol was done in an attempt to achieve optimal primary implant stability.

In all study groups, barrier membrane (GENOSS, South Korea) placed directly below the elevated SM and extended outside to cover the lateral window. Partial augmentation of the created subantral space with one the optional graft materials according to the groups. Installation of the DI (NucleOss T6, Turkey) into the prepared osteotomy site. Finally complete the augmentation of the created space.

PRF preparation:

Preparation of PRF was performed by collecting 10 mL of autogenous venous blood which was poured into 10 mL plain glass tube and immediately centrifuged. Centrifugation was performed according to the following two protocols: either at 2700 rpm for 12 min for preparation of L-PRF, or at 1500 rpm for 14 min for preparation of A-PRF [17,18]. Placing the PRF clot in a jar to be cut in small pieces with scissor and mixed with 1-2 cc DBB and being ready for sinus augmentation with one of these mixtures according to the study groups (B or C).

Implant stability measurement

Implant stability was measured by resonance frequency analysis test using Osstell ISQ device (Osstell; Gothenburg, Sweden) immediately after implant installation for baseline record (T1) and 24 weeks postoperatively (T2) before implant loading, as illustrated in figure 1. Two consecutive measurements, one from bucco-palatal and the other from mesiodistal direction for each implant were recorded. The mean of the two ISQ values was considered as the final primary ISQ (T1).

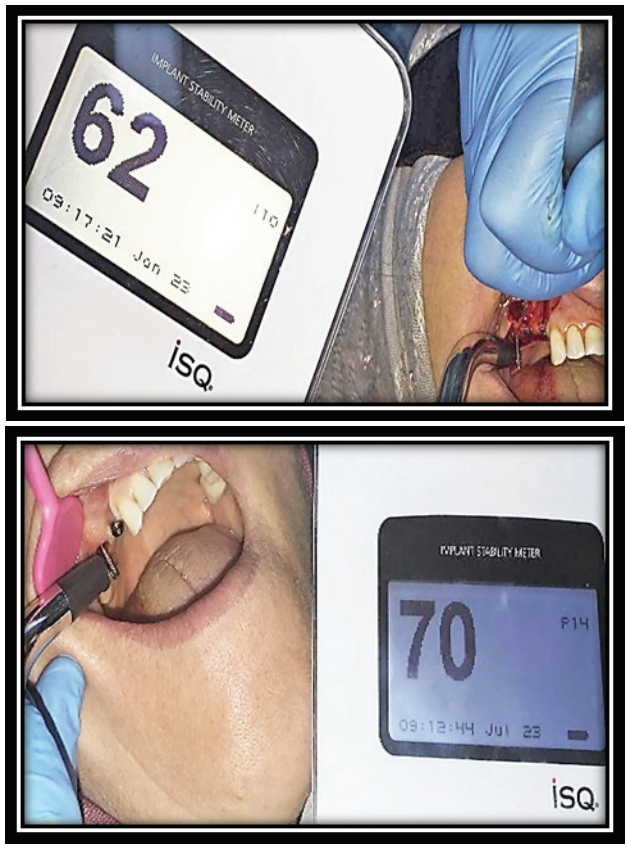

Figure 1: Osstell ISQ device for measurement of: (A) Primary implant stability (T1). (B) Secondary implant stability (T2).

Change in implant stability= Secondary implant stability (T2) - Implant stability (T1). Change in implant stability (%) = Change in implant stability (T2-T1) × 100% / Implant stability (T1).

Statistical Analysis

The new edition of IBM® SPSS® 24 was used for statistical analysis. The histogram revealed that the data was not distributed normally. The data is provided in the form of a mean and standard deviation. Kruskal-Wallis test was used to compare the mean stability of the groups. Wilcoxon Rank U test was used to assess changes within each category. The Mann-Whitney test is used to compare two different groups statistically. P value was considered not significant at $P > 0.05$, significant at $P \leq 0.05$ and highly significant at $P < 0.01$.

Results

Distribution of inserted dental implants according to the study groups

A total of 34 LSA procedures and simultaneous installation of DI (one-stage technique). The total number of DI installed concomitantly with the LSA for all study groups were 50 DI. Twenty-nine DI (58%) of which with a diameter of 4110 mm. Forty-six DI (92%) out of 50 DI were inserted in molar region (tables 2).

Table 2: Distribution of dental implants according to the study groups.

Study groups	No. of DI	Implant dimension (mm)					Implant inserted region and site					
							Molar				Premolar	
		35 10	41 10	41 12	48 10	48 12	2	3	14	15	5	13
		Frequency					Frequency					
A	21	3	12	3	1	2	4	4	7	5	0	1
B	16	1	8	5	2	0	1	2	4	6	2	1
C	13	1	9	1	1	1	3	6	2	2	0	0
Total No.	50	5	29	9	4	3	8	12	13	13	2	2
%	100	10	58	18	8	6	16	24	26	26	4	4

DI, dental implants.

Dental implant stability and study groups

Table 3 illustrates that the ISQ value increased significantly for all study groups from T1 to T2 (P= 0.001). For groups A and B, the statistical increase in stability was relevant with the increase in clinical ISQ scale (from low to medium stability, according to ISQ scale). In contrast, the significant increase in DI stability for group C was irrelevant clinically (within the medium ISQ scale).

Table 3: Implant stability measurement and mean change for each study group.

Study groups	No. of DI	Implant stability quotient (ISQ)			
		T1 Mean ±SD (Min-Max)	T2 Mean ±SD (Min-Max)	T2-T1 Mean change & (%)	P- value*
A	21	56.93 ±12.01 (31.5-68.5)	69.17 ±5.10 (52.5-75.0)	12.24 (21.5)	0.001
B	16	58.34 ±12.82 (28.0-70.5)	69.43 ±5.32 (58.0-75.0)	11.09 (19.0)	0.001
C	13	61.35 ±8.47 (40.5-70.0)	68.50 ±7.44 (49.0-75.0)	7.15 (11.6)	0.001
Total	50	58.87 ±11.1 (28-70.5)	69.03 ±5.95 (49-75)	10.16 (17.37)	0.001

*, Wilcoxon Signed Rank test.

Table 4 presents no statistically significant difference (P > 0.05) in ISQ values between the study groups at T1, T2 and in mean change (T2-T1).

Table 4: Implant stability measurements and mean changes between the study groups.

Study groups	No. of DI	Implant stability quotient (ISQ)						
		T1 Mean ±SD (Min-Max)	P Value*	T2 Mean ±SD (Min-Max)	P Value*	T2-T1 Mean change		P Value*
						ISQ	%	
A	21	56.93 ±12.01 (31.5-68.5)	0.52	69.17 ±5.10 (52.5-75.0)	0.901	12.24	21.5	0.45
B	16	58.34 ±12.82 (28.0-70.5)		69.43 ±5.32 (58.0-75.0)		11.09	19.0	
C	13	61.35 ±8.47 (40.5-70.0)		68.50 ±7.44 (49.0-75.0)		7.15	11.6	
Total	50	P** (A&B) = 0.45 P** (A&C) = 0.27 P** (B&C) = 0.84		P** (A&B) = 0.63 P** (A&C) = 0.83 P** (B&C) = 0.91		P** (A&B) = 0.79 P** (A&C) = 0.20 P** (B&C) = 0.42		

*, Kruskal-Wallis test; **, Mann Whitney U test.

Relation of implant stability to patient-related variables

The ISQ value was highly significant increase in both gender and age groups from T1 to T2. Moreover, the mean change reveals that females had a statistically significant increase in ISQ value in comparison to males (table 5).

Table 5: Relation of implant stability with gender and age variables.

Variables		No. of DI	Implant stability quotient (ISQ)						
			T1 Mean ±SD (Min-Max)	P-Value*	T2 Mean ±SD (Min-Max)	P-Value*	T2-T1 Mean change	P-Value*	P- value **
Gender	Male	22	61.57 ±8.93 (37.0-69.5)	0.14	69.11 ±5.82 (49.0-75.0)	0.84	7.54	0.03	0.0001
	Female	28	56.14 ±12.7 (28.0-70.5)		69.05 ±5.79 (52.5-75.0)		12.91		0.0001
Age (years)	< 40	9	53.78 ±14.33 (28.0-68.5)	0.26	65.78 ±7.31 (52.5-75.0)	0.10	12.0	0.48	0.008
	≥ 40	41	59.57 ±10.58 (31.5-70.5)		69.80 ±5.17 (49.0-75.0)		10.23		0.0001

*, Mann Whitney U test; **, Wilcoxon Signed Rank test.

Relation of implant stability to surgical-related variables

Table 6 reveals that there was a statistically significant increase in ISQ value for each surgical-related variable from T1 to T2. Furthermore, a highly significant increase in ISQ values for RBH < 4 mm in comparison to RBH ≤ 4 mm at T2 (P= 0.005).

Table 6: Implant stability and relation to surgical related variables.

Variables	No. of DI	Implant stability quotient (ISQ)						
		T1 Mean ±SD (Min-Max)	P-value *	T2 Mean ±SD (Min-Max)	P-value *	T2-T1 Mean change	P-Value *	P- value **
RBH (mm)								
≤ 4	11	53.63 ±13.23 (28.0-67.0)	0.05	65.13 ±6.93 (49.0-71.0)	0.005	11.5	0.60	0.003
> 4	39	59.91 ±10.61 (31.5-70.5)		70.19 ±4.91 (52.5-75.0)		10.28		0.000
DI insertion site								
Premolar	4	55.25 ±19.72 (28.0-70.5)	0.74	67.0 ±9.24 (58.5-75.0)	0.93	11.75	0.54	0.000
Molar	46	58.81 ±10.7 (31.5-70.0)		69.26 ±5.46 (49.0-75.0)		10.45		0.000
DI diameter (mm)								
3.5	6	57.67 ±15.56 (28.0-70.5)	0.62	67.33 ±6.89 (58.5-75.0)	0.871	9.66	0.17	0.028
4.1	37	59.37 ±10.81 (31.5-70.0)		69.45 ±5.28 (49.0-75.0)		10.08		0.000
4.8	7	54.78 ±11.7 (38.0-68.5)		68.57 ±7.6 (52.5-74.0)		13.79		0.018

RBH, Residual bone height; *, Mann Whitney U test; **, Wilcoxon Signed Rank test.

Discussion

The implant stability quotient (ISQ) value ranges from 1 to 100. In general, ISQ values for successful implants are reported from 57 to 82 ISQ [13,14]. The ISQ> 70 represents high stability, ISQ between 60 and 69 exemplify medium stability, and ISQ< 60 ISQ considered low stability [19].

In the present research, the results were considered clinically significant or not dependent on the number of DI that remained in the same level of ISQ-scale or changed to another level. This clinical analysis of the data illustrated and confirmed that not all the statistically significant results essentially being clinically relevant. This idea is supported by Guller in 2008 [20] who declared that statistically significant differences may be of no clinical relevance whatsoever".

The implant survival was 100%. For all study groups, there was a significant increase in ISQ value from 58.78 ±11.1 ISQ (low stability) at T1 to 69.03 ±5.95 ISQ (medium stability) at T2 with a mean change of DI stability (10.16 ISQ), in which it was statistically significant and clinically relevant.

For study groups A and B, there was a statistically significant increase in stability from T1 to T2 which was harmonious with the clinical outcome (increase of ISQ values from low to medium stability level). In contrast, the statistically significant increase in ISQ value for group C was not associated with clinical relevance (ISQ values remained within medium stability level).

The statistically significant increase in stability from T1 to T2 for all study groups might be related to the increase in osseointegration. This outcome is supported by Sennerby et al. in 2005 [21] who claimed that the increased ISQ values might be attributed to the successfully osseointegrated implants.

Undersized drilling protocol was accomplished in the maxillary posterior region to gain the requested primary implant stability. This method was enforced by several studies which proved that when DI were inserted in underprepared osteotomy sites using smaller diameter drills, maximum bone volume preservation and enhanced bone density were achieved as stated by Turkyilmaz et al. in 2008 [22], Tabassum et al. in 2010 [23].

No statistically significant difference (P > 0.05) noticed in ISQ values between the 3 study groups at T1, T2 and in mean change (T2-T1). Nevertheless, it was higher in groups A and B, 12.24 ISQ and 11.09 ISQ, respectively, when compared to group C (7.15 ISQ). However, it did not reach the level of statistical significance (P = 0.45).

In addition, it has been found that the addition of L-PRF and A-PRF to DBB for the study groups B and C, respectively; did not provide an enhancement to the ISQ value superior to the DBB alone in group A. This result comes in line with Pichotano and co-workers in 2019 [24], who found that the ISQ values at loading did not differ according to the grafting materials, following a split-mouth design, in which the right maxillary sinus was augmented using L-PRF mixed with DBB and the left side was filled with DBB alone. In contrast, Călin et al. in 2016 [25] claimed that the use of the combination of A-PRF and bovine bone in sinus lift technique speeded healing time by approximately 50%. However, the authors in their study relied the assessment of implant osseointegration on clinical examination and panoramic radiograph and they did not measure the DI stability.

Relation of implant stability to patient-related variables

For all study groups, and from a statistical point of view, there was a highly significant increase in the ISQ value for gender and age variables from T1 to T2. The speculation might be related to the normal remodeling process during osseointegration in which the stability increased during time depending on primary stability and other factors as bone remodeling and implant surface conditions as proclaimed by Sachdeva et al. in 2016 [14].

Relation of implant stability to surgical-related variables

In this research, the effect of some factors on implant stability were standardized by operating on the same region (posterior maxilla), standard surgical technique (LSA), the same implant system (geometry

and surface characteristics) utilized for all cases, the same surgeon, undersized drilling technique that is to reduce the confounding factors that might influence implant stability.

There was a statistically significant increase in ISQ value for each surgical-related variable (RBH, DI insertion site, and DI diameter) from T1 to T2. This was ordinarily related to the normal sequelae of healing process and osseointegration since stability of DI increased in all surgical-related variables.

The RBH < 4 mm demonstrated a statistically significant increase in implant stability versus RBH ≤ 4 mm at T1 and T2. This result is supported by several studies which concluded that primary implant stability is influenced by quality and quantity of the residual bone, and the secondary implant stability in its turn affected by the primary stability [12,16,26].

Conclusion

There was a significantly increase in ISQ value for all of the DI 24 weeks after their installation irrespective to the type of graft material utilized to augment the sinus. Moreover, the addition of L-PRF or A-PRF to the bovine bone for sinus floor augmentation did not increased the ISQ value superior to the bovine bone alone.

Ethical Clearance

The Research Ethical Committee at scientific research by ethical approval of both MOH and MOHSER in Iraq

Conflict of Interest: None

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