Clinical Outcomes and Stability Changes Associated With Immediate loading Of Two Different Installation Protocols

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Abstract:

Problem statement

The wide variation of implant installation protocols combined with immediate implant loading have a pivotal impact on implant stability and success. This study was conducted to assess immediate implant loading on stability changes and clinical outcomes of two different installation protocols.

Patient and Method: Sixteen patients; nine females and seven males seeking for dental implants and patient were divided equally into two groups. In 1st group, eight dental implants were placed 6-8 weeks after extraction of non-restorable tooth in the lower posterior region. While, in 2nd group, eight dental implants were placed in healed sites (more than 3 months) after extraction in the lower posterior region. All implants were subjected to immediate loading within (48-72) hours after fixture installation. All patients were assessed clinically either at baseline (T0), 3 months (T1), at 6 months (T2) and 12 months (T3) of follow up regarding to Implant stability by Osstell and Periotest, radiographically for assessment of marginal bone level (MBL). Modified bleeding index, Modified plaque index and peri-implant pocket depth were assessed at the same time intervals of evaluation.

Result: There was significant differences were recorded between both groups regarding to implant stability by osstell at (T0) (P=0.004). However, there were no statistical significant differences recorded at (T1) and (T2) intervals of follow up (P=0.870, 0.201 respectively), on other hand, periotest value showed no statistical significant differences between both groups at (T0), (T1), (T2) and (T3) (P=0.490, 0.914, 0.063 and 0.098 respectively). A significant correlation was established between ISQ and PTVs at (T0) in control group in comparison with lack of significant correlation between both of ISQ and PTVs in study group for same time interval of assessment. No significant differences were recorded between both groups regarding to mSBI, PI, MBL and PIPD at different time intervals of follow up periods either at, (T0), (T1), (T2) and (T3) (P=1.000, 0.880, 0.838 and 0.077 respectively), (P=1.000, 0.789, 0.838 and 0.211 respectively), (P=0.400, 0.863 and 0.136 respectively) and (P=0.099, 0.204 and 0.080 respectively),.

Conclusion: Osstell and Periotest systems proved to be a sensitive implant stability assessment tools. However, Osstell can be considered as a more precise and reliable fingerprint tool rather than periotest, especially when immediate loading pattern will be used.

Key Words: Osstell&Periotest systems, immediate loading, and implant stability.

Introduction

Teeth replacement using dental implants has proven to be a successful and predictable treatment procedure. Different placement and loading protocols have evolved from the first protocols in order to achieve quicker and easier surgical treatment times. [1] Dental implants can be placed in sockets just after tooth extraction (immediate implants) or after a couple of weeks up to a couple of months (immediate-delayed implants) or thereafter (delayed implants). [2]

Reductions in the number of surgical interventions, a shorter treatment time, an ideal three dimensional implant positioning, preservation of alveolar bone at the side of the tooth extraction and soft tissue aesthetics have been claimed as the potential advantages of this treatment approach. [3] However, the delayed immediate implant may share some of the advantages of immediate placement, mainly by utilizing the socket walls before they become fully resorbed, but at the sametime allowing primary healing after tooth extraction and thus achieving enough soft tissues for flap closure and reducing the risks for infection. [4]

Implant stability was considered to maintain the capacity to withstand loading from axial, lateral, and rotational directions. [5,6] Therefore, maintaining implant stability is an essential condition for the successful clinical outcome of implants. Primary stability has been applied as an indicator of future osseointegration. [7] Greater primary stability enables uninhibited healing because of little micromotion between implants and bone. [8,9]

Various methods were suggested to evaluate the initial bone quality and the degree of osseointegration, [10] including histology and histomorphometry, [11,12,13] removal torque analysis, [14,15] pull- and push-through tests [16] and X-ray examination. [17] However, due to problems of invasiveness and inaccuracy, these methods are not suitable for long-term clinical assessment. To overcome these problems, a noninvasive device called the Periotest was used to monitor the implant stability. [18,19]

Unfortunately, as the Periotest value is strongly related to the excitation direction and position, the reading from the method does not always correspond precisely to a biomechanical parameter [20,21] Due to the need for a nondestructive and noninvasive device to evaluate the conditions of implant–bone interface, a new device Osstell which based on Resonance Frequency Analysis (RFA) was developed. [10]

Several authors favored delayed placement of implants rather than immediate protocols which subsequently has an impact factor on primary stability and implant success. [22-24] Based on the aforementioned data, it is believed to be of interest to assess immediate implant loading on stability changes and clinical outcomes of two different installation protocols.

Patients and Methods

Sixteen patients; nine females and seven males, seeking for replacement of single missing mandibular premolar or molar teeth.

All patients included in this study were equally divided into two main equal groups. In **study group (I)** eight patients received single implant for each one, within 6-8 weeks after tooth extraction in the lower posterior region. *While, in* **control group (II)** eight patients received single implant for each one in healed sites (more than 3 months) after extraction in the lower posterior region. Patients in both groups were received final restoration with immediate functional loading within 48-72 hours after implant installation.

Surgical procedures

Preoperative periapical radiographs were taken for all patients to verify the bone height, and the implantation site. Prophylactic antibiotic of 1 gm amoxicillin + clavulanic acid (**Curam®, SANDOZ**) was taken, one gram tablet the day before and 2 hours before surgery. After local anesthesia administration (**Artinibsa; Inibsa, Lliça de Vall, Spain**) a traumatic extraction procedure was performed in group (I). After tooth extraction, careful examination of the socket for any tooth fragments or granulation tissue and copious irrigation with saline solution was performed to allow socket to heal spontaneously for 6-8 weeks.

After 6-8 weeks of healing period in group (I) and 3 months in group (II). A marginal incision was made and extended bucally and lingually one tooth mesial and one tooth distal followed by buccal and lingual flap reflection.

The initial osteotomy was done using the pilot drill to the desired depth. The accurate drilling direction was guided by the surgical drill guide till the desired dimension was achieved. After irrigation of the implant bed with saline the selected implant size and length was carefully guided into the osteotomy site with ratchet for complete installation of implant to its final position. Then, repositioning of flap was done and sutured in an interrupted manner. The final position of the implant was confirmed by immediate periapical radiograph which act as a baseline for comparison. After laboratory fabrication of the porcelain fused to metal crown, the final cementation of permanent crown was carried-out within 72 hours.

Clinical Evaluation

All patients contributed in the study were assessed immediately after crown cementation, three, six and twelve months postoperatively according to the following criteria:

(1) Implant stability assessment

Implant stabilty in all patient were assessed by two method as following:

➤ **ISQ (Implant stabilty quotient)**

The stability of an implant was measured by ISQ which is a scale from 1 to 100. [6] Scales >70 ISQ indicated high stability, scales among 60-69 indicated medium stability and scales <60 ISQ measured as low stability. Readings were taken immediately after fixture installation before crown attachment (T_0), after three months (T_1) and after six months from crown attachment (T_2) for each case included in the study.

➤ **periotest (Damping capacity assessment)**

The PTVs score have 3 grades, [25] grade (I) varies from -08 to 0 and indicated to good osseointegration, grade (II) varies from +1 to +9 and indicated to need for clinical examination and pressure on implant not yet possible and grade (III) varies from +10 to +20 and indicated to insufficient osseointegration. Readings were taken immediately after fixture installation and crown attachment (T0), after 3 months (T1), after 6 months (T2) and after 12 months (T3) from crown attachment for each case included in the study.

2) Modified Sulcus Bleeding Index

The *mSBI* have 4 scores according to the following, [26] score (0) no bleeding with periodontal probe, score (1) visible spot bleeding, score (2) blood forms a confluent red line on margin and score (3) heavy or profuse bleeding.

(3) Modified Plaque Index

The *PI* have 4 scores according to the following, [26] score (0) plaque not detected, score (1) Plaque only recognized by running a probe across the margins, score (2) Plaque can be seen by the naked eye and score (3) Abundance of soft matter.

(4) Peri implant pocket depth

Recordings were approximated to the nearest 0.5mm. [27] Placing the periodontal prope parallel to the long axis of the implant until reached the most apical point of the pocket. Mesiobuccal, mid-buccal, distobuccal and mid-palatal pocket depths were collected and the average mean of the 4 measurements were recorded

(5) Radiographic Evaluation

Marginal bone loss (MBL) was assessed by intraoral periapical radiographs using the long cone paralleling technique and all radiographs were taken with the same device and transferred with the same program to standardize the result. Evaluation of peri-implant bone loss was done immediately (T_0), after 3 months (T_1), after 6 months (T_2) and after 12 months (T_3) respectively in both groups after all titanium implant placement and crown attachment. [28]
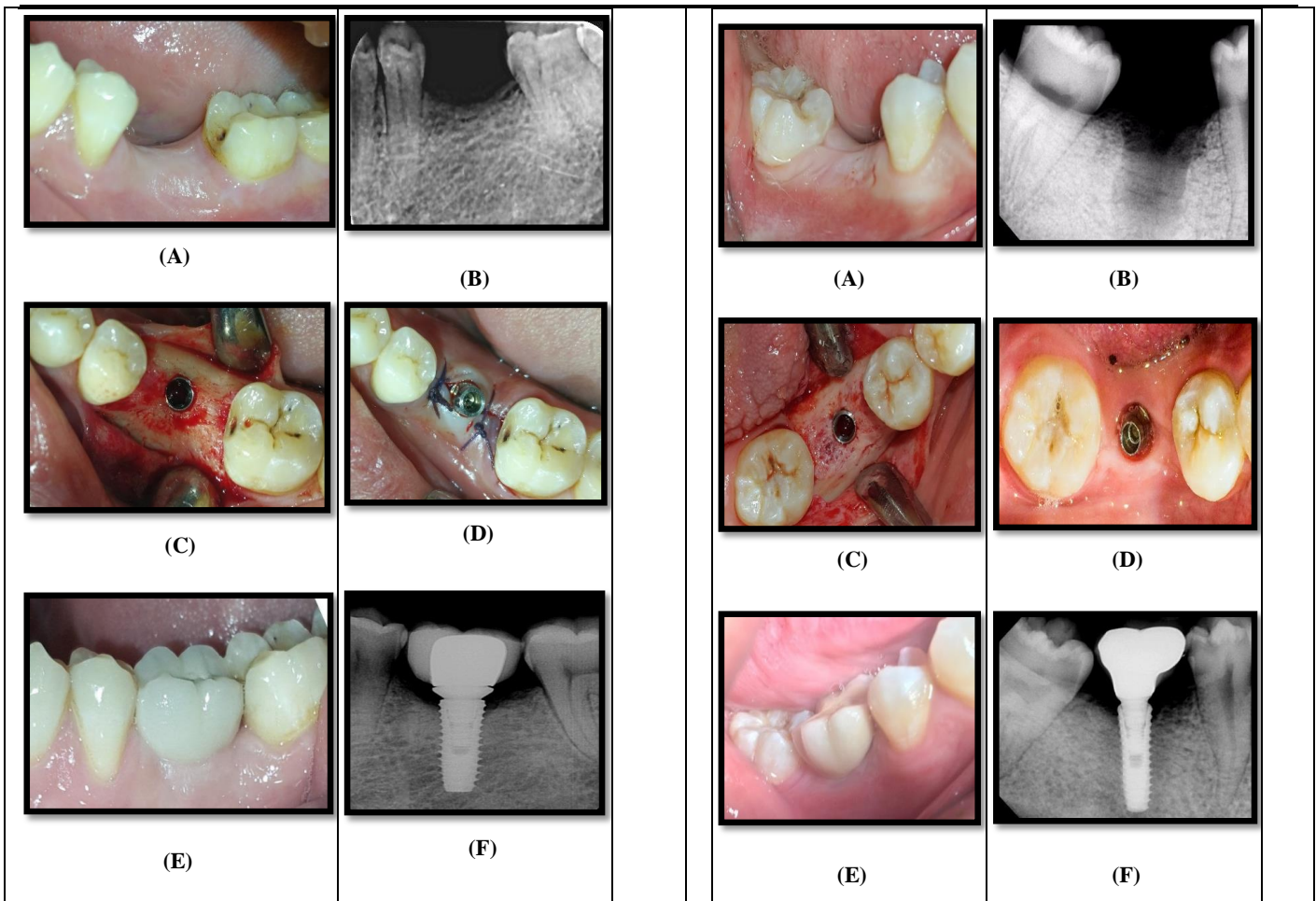
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Fig.1.A. showing preoperative intraoral view of missing mandibular left first molar. **1.B.** Preoperative periapical radiograph to verify the bone height. **1.C.** Implant inserted into osteotomy site and flushed with bone level. **1.D**. Abutment connected to fixture before final porcelain fused to metal crown cemented permanently. **1.E.**Buccal view of final restoration **1.F.** A peri-apical digital x-ray revealing MBL around mini-implant after 12 months follow up in the 1st group.

Fig.1.A. showing preoperative intraoral view of missing mandibular right first molar. **1.B.** Preoperative periapical radiograph revealing incomplete ossification after 8 weeks from extraction. **1.C.** Implant inserted into osteotomy site and flushed with bone level. **1.D**. Abutment connected to fixture before final porcelain fused to metal crown cemented permanently. **1.E.** Buccal view of final restoration **1.F.** A peri-apical digital x-ray revealing MBL around mini-implant after 12 months follow up in the 2nd group.

Statistical Analysis

Data were fed to the computer and analyzed using IBM SPS software package version 20.0. **(**Armonk, NY: IBM Corp**)** Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level.

Results

Demographic data

This study was conducted on sixteen patients with an average age 35±6 divided in two equal groups. One first premolar (6.25%), three second premolar (18.75%) and twelve first molar (75%) were included within this study and uniformly distributed into both groups. All implants were subjected to immediate loading within (48-72) hours after fixture installation in 1st group, one of the implants exhibited mobility and failed after 3 months from loading after fixture installation even with meticulous oral hygiene preservation, mouth wash, analgesic and antibiotics usage to minimize gingival inflammation and pain. But in 2nd group none of the implants exhibited mobility.

All patients in both groups were assessed clinically at different time intervals of follow up regarding to the included parameters.

(2)   Implant stability assessment
Implant stability in all patient were assessed by two method as following:

➢ **ISQ (Implant stability quotient)**

In 1st group, at (T0) the mean ISQ value was 76.50±2.56. At (T1), the mean ISQ value was 77.29±4.11. At (T2), the mean ISQ value was 79.57±3.21. In 2nd group, at (T0) the mean ISQ value was 80.88±2.59. At (T1), the mean ISQ value was 77.63±3.78. At (T2), the mean ISq value was 81.50±2.33.

Comparing both groups, there was statistically significant differences at (T0) (P=0.004). However, there were no statistically significant differences recorded at (T1) and (T2) intervals of follow up (P=0.870, 0.201 respectively) **(Table 1).**

Table (1):   Showing mean, standard deviation and level of significance between both groups at different time intervals of follow up regarding to implant stability quotient (ISQ).

Patient group / Time of assessment		Implant Stability Assessment by (Osstell Data)		
		(T_0)	(T_1)	(T_2)
Study group	Mean ± SD.	(n = 8)	(n = 7)	(n = 7)
		76.50 ± 2.56	77.29 ± 4.11	79.57 ± 3.21
Control group	Mean ± SD.	(n = 8)	(n = 8)	(n = 8)
		80.88 ± 2.59	77.63 ± 3.78	81.50 ± 2.33
P		0.004*	0.870	0.201

➢ **Periotest (Damping capacity assessment)**

In 1st group, at (T0) the mean periotest value was -2.38±0.52. At (T1), the mean periotest value -2.43±0.79. At (T2), the mean periotest value was -2.14±0.38. At (T3), the mean periotest value was -3.14±0.38. In 2nd group, at (T0) the mean periotest value was -2.88±1.89. At (T1), the mean periotest value was -2.38±1.06. At (T2), the mean periotest value was -2.63±0.52. At (T3), the mean periotest value was -2.75±0.46.

Comparing both groups, there were no statistically significant differences at (T0), (T1), (T2) and (T3) (P=0.490, 0.914, 0.063 and 0.098 respectively) **(Table 2).**

Table (2):   Showing mean, standard deviation and level of significance between both groups at different time intervals of follow up regarding to periotest value (PTVs).

Patient group / Time of assessment		Implant Stability Assessment by (periotest Data)			
		(T_0)	(T_1)	(T_2)	(T_3)
Study group	Mean ± SD.	(n = 8)	(n = 7)	(n = 7)	(n = 7)
		-2.38 ± 0.52	-2.43 ± 0.79	-2.14 ± 0.38	-3.14 ± 0.38
Control group	Mean ± SD.	(n = 8)	(n = 8)	(n = 8)	(n = 8)
		-2.88 ± 1.89	-2.38 ± 1.06	-2.63± 0.52	-2.75 ± 0.46
p		0.490	0.914	0.063	0.098

Measuring implant stability by two different devices (osstell and periotest), revealed significant correlation between ISQ and PTVs at (T0) in control group (P= o.o29). On the other hand, there was no significant correlation between both ISQ and PTVs in study group for same time interval of assessment **(P= 0.519) (Table 3).**

Table (3): Showing correlation between ISQ and PTVs in each group at different time intervals of follow up.

Patient group / Time of assessment		Implant Stability Assessment by (ISQ vs. PTVs)		
		(T_0)	(T_1)	(T_2)
Study group	r	0.269	0.044	-0.196
	p	0.519	0.925	0.673
Control group	r	-0.758	0.174	0.178
	p	0.029*	0.681	0.674

2) Modified Sulcus Bleeding Index (*mSBI*)

In 1st group, at (T0) the mean value was 1.50 ± 0.53. At (T1), the mean value was 0.63 ± 0.52. At (T2), the mean value was 1 ± 0.76mm. At (T3), the mean value was 0.63 ± 0.52mm. In 2nd group, at (T0) the mean value was 2.13 ± 0.64. At (T1), the mean value was 0.75 ± 0.46. At (T2), the mean value was 0.88 ± 0.64mm. At (T3), the mean value was 0.63 ± 0.52mm.

Comparing both groups, there were no statistically significant differences found between values recorded at the different time intervals of follow up either at, (T0), (T1), (T2) and (T3) (P=1.000, 0.880, 0.838 and 0.077 respectively) (Table 4).

Table (4): Showing mean, standard deviation and level of significance between both groups at different time intervals of follow up regarding to modified sulcus bleeding index (BI)

Patient group / Time of assessment		Modified sulcus bleeding index (BI)			
		(T_0)	(T_1)	(T_2)	(T_3)
Study group	Mean ± SD.	(n = 8) 1.50 ± 0.53	(n = 7) 0.71 ± 0.49	(n = 7) 0.43 ± 0.53	(n = 7) 0.57 ± 0.53
Control group	Mean ± SD.	(n = 8) 1.50 ± 0.53	(n = 8) 0.75 ± 0.46	(n = 8) 0.38 ± 0.52	(n = 8) 0.13 ± 0.35
P		1.000	0.880	0.838	0.077

(3) Modified Plaque Index (PI)

In 1st group, at (T0) the mean value was 1.13 ± 0.64. At (T1), the mean value was 1.25 ± 0.89. At (T2), the mean value was 1.0 ± 0.53. At (T3), the mean value 0.63 ± 0.52. In 2nd group, at (T0) the mean value was 0.88 ± 0.64. At (T1), the mean value was 0.88 ± 0.35. At (T2), the mean value was 1.38 ± 0.74. At (T3), the mean value was 0.63 ± 0.52mm. Comparing both groups, there were no statistical significant differences found between values recorded at the different time intervals of follow up either at, (T0), (T1), (T2) and (T3) (P=1.000, 0.789, 0.838 and 0.211 respectively) (Table 5).

Table (5): Showing mean, standard deviation and level of significance between both groups at different time intervals of follow up regarding to modified plaque index (PI)

Patient group / Time of assessment		Modified plaque index (PI)			
		(T_0)	(T_1)	(T_2)	(T_3)
Study group	Mean ± SD.	(n = 8) 0.0 ± 0.0	(n = 7) 0.43 ± 0.53	(n = 7) 0.43 ± 0.53	(n = 7) 1.0 ± 0.82
Control group	Mean ± SD.	(n = 8) 0.0 ± 0.0	(n = 8) 0.50 ± 0.53	(n = 8) 0.38 ± 0.52	(n = 8) 0.50 ± 0.76
p		1.000	0.789	0.838	0.211

(4) Peri implant pocket depth (PPD)

In 1st group, at (T0) the mean PPD value was 1.13 ± 0.23. At (T1), the mean PPD value was 0.79 ± 0.27. At (T2), the mean PPD value was 0.64 ± 0.24. At (T3), the mean PPD value 0.50 ± 0.0. In 2nd group, at (T0) the mean PPD value was 1.44 ± 0.42. At (T1), the mean PPD value was 1.06 ± 0.18. At (T2), the mean PPD value was 0.81 ± 0.26. At (T3), the mean PPD value was 0.69 ± 0.26.

Comparing both groups, there was statistically significant difference found between values recorded at (T1) (P=0.036). On the other hand, there were no statistically significant differences found between values recorded at the other different time intervals of follow up periods either at, (T0), (T2) and (T3) (P=0.099, 0.204 and 0.080 respectively) (Table 6).

Table (6): Showing mean, standard deviation and level of significance between both groups at different time intervals of follow up regarding to peri-implant pocket depth (PPD)

Patient group / Time of assessment			Peri-implant pocket depth (PIPD)			
			(T_0)	(T_1)	(T_2)	(T_3)
Study group	Mean ± SD.		(n = 8) 1.13 ±0.23	(n = 7) 0.79 ±0.27	(n = 7) 0.64 ±0.24	(n = 7) 0.50 ±0.0
Control group	Mean ± SD.		(n = 8) 1.44 ±0.42	(n = 8) 1.06 ±0.18	(n = 8) 0.81 ±0.26	(n = 8) 0.69 ±0.26
p			0.099	0.036*	0.204	0.080

5- Marginal Bone Level (MBL)

In 1st group, at (T1), the mean MBL value was 0.60 ± 0.13 mm. At (T2), the mean MBL value was 0.67 ± 0.13mm. At (T3), the mean MBL value 0.87 ± 0.19 mm. In 2nd group, at (T1), the mean MBL value was 0.50 to 0.70 mm. At (T2), the mean MBL value was 0.69 ± 0.21mm. At (T3), the mean MBL value was 1.05 ± 0.24mm.

No statistically significant differences were recorded between both groups regarding to marginal bone level recorded at the different time intervals of follow up either at, (T1) or at (T2) and (T3) (P=0.400, 0.863 and 0.136 respectively) (Table 7).

Table (7): Showing mean, standard deviation and level of significance between both groups at different time intervals of follow up regarding to marginal bone level (MBL)

Patient group / Time of assessment			Marginal bone level (MBL)		
			(T_1)	(T_2)	(T_3)
Study group	Mean ± SD.		(n = 7) 0.60 ± 0.13	(n = 7) 0.67 ± 0.13	(n = 7) 0.87 ± 0.19
Control group	Mean ± SD.		(n = 8) 0.55 ± 0.09	(n = 8) 0.69 ± 0.21	(n = 8) 1.05 ± 0.24
P			0.400	0.863	0.136

DISCUSSION

Reduction of the overall treatment time implant therapy following tooth extraction is the major challenge for contemporary dental implantologists. This approach includes a soft tissue healing period of 6 to 8 weeks after extraction prior to implant placement to provide oral rehabilitation to patients with healthy bone conditions, [29,30] which increase osteoblastic activity in the extraction site leading to narrow the socket and improve the chances of osseointegration. [31]

Basically, RFA Osstell system proved to be more reliable compared to periotest system in measuring dental implant stability in hard and soft interfaces. [32-34] In our study, the mean value for ISQ of patient within study group ranged between 76.50±2.56 to 79.57±3.21 at T0 and after 6 months of follow up, and for control group were ranged between 80.88±2.59 to 81.50±2.33 at T0 and after 6 months of follow up.

In accordance with our study **Indjova, J et al. 2014,** [35] used ISQ value as a monitoring tool to compare the stability of immediately, delayed immediate and conventional placed implants in dogs and declared that the highest

implant stability was exhibited by conventional protocols with a high statistically significant difference against both of immediate and delayed immediate implant. Moreover, the stability of delayed immediate was the lowest versus both of conventional and immediate protocol.

Additionally, with regard to ISQ value, a statistically significant difference was recorded when comparing both groups only at T0 (P=0.004). However, no statistically significant differences were established at the other time intervals of assessment either at T1 or T2 (P=0.870, 0.201 respectively). Such finding can be attributed to the relative lower primary stability of delayed immediate versus conventional implant resulted from the cumulative effect of two pattern of traumas; tooth extraction and implant placement in an already impaired biological environment.

Regarding to implant stability assessment by periotest, the mean periotest values (PTVs) of patient within study

group ranged between -2.38±0.52 to -3.14±0.38 at T0 and after 12 months of follow up, and for control group they were ranged between -2.88±1.89 to -2.75±0.46 at T0 and after 12 months of follow up. These results were in

agreement with **Atsumi et al., 2007** who declared that PTVs ranged between -4 to -2 reflect a suitable primary stability for immediate loading pattern. [36]

On the other hand, there was no statistically significant differences recorded regarding to PTVs when comparing both groups at any time intervals of follow up (P=0.490, 0.914, 0.063 and 0.098 respectively). Our finding reveled that timing of implant placement either in delayed or delayed immediate did not have a significant impact on primary stability when assessed by periotest.

Moreover, **Oh et al., 2009** examined the usefulness of periotest and osstell on dogs after delayed immediate implant placement (4 weeks after extraction). Oh et al., declared that, the PTV value was lower and ISQ value was higher at 6 weeks when compared with data collected after 3 weeks from implantation. [37]

The wide variation of the PTVs recorded at the different time intervals of assessment either by an increase at (T1) that can be attributed to the effect of early loading impact on bone remodeling and stability. [38] However, the decrease of PTVs established at (T2) was in accordance with **Kim et al 2009**[39] who concluded that implant stability increases overtime resulted from bone settlement and maturity at the bone-implant interface.

Regarding to the correlation between both of implant stability measuring tools (osstell and periotest), a significant correlation was revealed between ISQ and PTVs at (T0) in control group (P= 0.029). On the other hand, there was no significant correlation between ISQ and PTVs in study group for same time interval of assessment **(P= 0.519)**

The correlation between RFA and Periotest, was studied by **Zix et al., in 2008** and reported that the osstell instrument was more precise than periotest. [33] In addition, in vitro studies have reported that the two measurement methods showed a significant linear corelation. [27, 28] In contrary, another study performed by **Ji-Su Oh et al, in 2012** revealed a significant negative correlation between the ISQ values and PTVs (P= - 0.777). [40]

Regarding to marginal bone level (MBL), the average mean values of marginal bone level (MBL) in study group were ranged between 0.60 ± 0.13 recorded at (T1), 0.67 ± 0.13 at (T2) and 0.87 ± 0.19 at (T3). While, in control group the average mean values of MBL were ranged between 0.55 ± 0.09 recorded at (T1), 0.69 ± 0.21 at (T2) and 1.05 ± 0.24 at (T3). Our study revealed that most of this bone resorption occurred within the 6 and 12 months after loading. There were no statistically significant differences between both groups regarding to marginal bone level at the different time intervals of follow up either at, (T1), (T2) or at (T3) (P=0.400, 0.863 and 0.136 respectively).

In agreement with our findings Schropp et al., 2005 have compared the delayed immediate implant versus delayed implants with conventional loading around maxilla and mandible (anterior or pre-molar region). The average mean

of MBL was (0.8 and 0.7mm respectively) after nine months. The average mean of MBL was 1.5mm after two years of follow-up for both groups. They noted that most of bone resorption occurred within the first nine months of loading. [41]

Moreover, **Annibali et al., 2011** evaluated interproximal marginal bone loss adjacent to delayed immediate implant in mandibular or maxillary first molar sites. The average mean was (0.91±0.28mm) after nine months from baseline and after 22 months from baseline. (1.04±0.25mm). [42] Additionally, **Schropp et al., 2014** evaluated the radiographic peri-implant marginal bone loss through comparing early, delayed immediate and conventional protocol. They concluded no significant differences among all groups regarding implant survival and marginal bone level [43]

On the other hand, Halperin-Sternfeld et al., in 2016 revealed that the increase in peri-implant pocket depth is directly correlated with MBL. [44] Such declaration is in agreement with our study, that revealed no significant difference between both groups regarding to MBL with no statistically significant difference reported at (T0), (T2) or at (T3) regarding to peri-implant pocket depth (P=0.099, 0.204 and 0.080 respectively)

This finding was attributed to the use of periodontal probe for measuring peri-implant pocket depth that could not give the specific accurate record provided by the radiographic analysis. [45] Results were approximated to the nearest 0.5 mm, as it is difficult to assure a record below 0.5 mm using only the naked eye. This approximation narrowed to a great extent the variation between implants in both groups or even between implants within the same group.

Additionally, there was a statistically significant difference within both groups regarding to peri-implant pocket depth when comparing values recorded at (T0) against those values of either (T2) and (T3) (P=0.015, 0.004 respectively). This result was agreed with **Molina Villar et al 2017** who recorded a significant statistical difference between peri-implant pocket depths at the time of loading and after 6 months, resulted from the increase of the gingival height around cemented crowns. [46] This can be explained by the effect of early loading on the remodeling of peri-implant soft tissue. [47]

Another parameter indicating the state of gingival health is the modified sulcus bleeding index. The present study showed a stable peri- implant soft tissue and recorded no statistically significant differences between both groups at any time intervals regarding to Modified bleeding index at different time intervals of follow up (P=1.000, 0.880, 0.838 and 0.077 respectively). The gingival health was maintained throughout the study due to the strict oral hygiene instructions.

Historically, a longitudinal study showed weak correlation between bleeding index and peri-implant bone loss. [48] Also, **Lekholm et al.**, in **1986** found no correlation between bleeding-on-probing and histology, microbiology and radiographic changes. [49] While, others claim bleeding as an important indicator for disease. [50]

Regarding modified plaque index, no statistically significant differences were recorded between both groups at different time intervals (P= 1.000, 0.789, 0.838 and 0.211 respectively). This can be attributed to the plaque control by the patient and the frequent motivation of oral hygiene measures given to the patient. Moreover, **Lindquist et al., 1988** proposed that microbial film was correlated with the presence of plaque which act as an etiologic factor for implant diseases and may induce bone loss. [51] Therefore, the presence of plaque can be used as a predictor for disease and for planning intervention. [52]

Finally, we believe that both of implant stability assessment tools can be applied on a wide practical scale. However, osstell can be used as an early sensitive and reliable stability monitoring tool applied with critical risky treatment protocols such as subjecting to early loading pattern or within locally compromised osteotomy site.

Conclusion:

Osstell and Periotest systems proved to be sensitive implant stability assessment tools. However, Osstell can be considered as a more precise and reliable fingerprint tool rather than periotest, especially when immediate loading pattern will be used.

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