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CORRELATION BETWEEN TWO IMPLANT STABILITY MEASUREMENT TOOLS AND MARGINAL BONE REMODELING OF IMMEDIATELY LOADED IMPLANT USED IN TWO DIFFERENT BONE QUALITIES

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ABSTRACT

Problem statement: Dynamic remodeling occurs at bone-implant interface during osseintegration has represented the development of non invasive but relatively accurate clinical tools to assess implant stability and their possibility to load on. So, this study was directed to evaluate correlation between Periotest and Ostell as an implant stability measuring tools and the marginal bone level changes of immediately loaded implant used in two different bone qualities.

Patients and Methods: Fourteen patients received sixteen implants forming a common pool were divided into two equal harmoniously distributed groups of single missing tooth presented within either posterior maxilla or mandible. All patients within both groups received crown that was fabricated and temporarily seated within occlusion for 6 months. All patients included in this study were evaluated clinically for measuring implant stability using both of periotest and Ostell and radiographically for assessment of marginal bone level changes at 3 and 6 months.

Results: In both groups, there was statistical significant difference when comparing the (MBL) values obtained at 3 months with that recorded at 6 months either within posterior maxilla or mandible (P=0.015- 0.005 respectively). Regarding to PTVs and ISQ values, a statistical difference was recorded between both groups at the different times of follow up either at 3 or 6 months respectively (P= 0.000). In 2nd group, a positive significant correlation was revealed between PTVs and marginal bone level (MBL) recorded after 3 months (P=0.036).

Conclusion: Posterior mandibular bone revealed an early positive significant correlation between PTVs and ISQ in comparison with posterior maxilla. Additionally, an early positive significant correlation has been established between PTVs and MBL in maxilla.

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INTRODUCTION

Wide variation of different bone qualities has represented a dynamic challenging process that can affect the degree of osseointegration. Such variation showed that soft bone sites often develop an increased anchorage over time, but the more dense bone structure incorporated at surgery, the more initial anchorage can be obtained. [1]Clinical studies reported that bone remodeling will take place once sufficient primary implant stability and a controlled loading situation is established, since the osseointegration process represented as a transformation from mechanical to biological stability. [2-4]

Basically, initial bone quality and degree of osseointegration can be assessed through utilization of different alternative methods,[5] including histology and histomorphometry [6-8] removal torque analysis,[9-11] pull- and push-through tests [12] and X-ray examination.[13]

Several devices were developed to evaluate implant stability (Osstell and Periotest instruments) that differs substantially regarding to their scientific basis. However, the importance of both methods as a useful tool through long-term follow-up of dental implant integration was documented.[14] It has been considered that both of periotest and Ostell can be applied clinically as a predictive tool for assessment the degree of the peri-implant bone loss which can be reflected as suitable method to detect a decrease in implant stability.[15,16]

Unfortunately, several studies declared that Periotest reading does not always reflect precisely the biomechanical parameter since periotest values (PTVs) are mainly related to the excitation direction and position. [17,18] On the other hand, the replacement of resonance frequency analysis (RFA)instead of Periotest™ technique in some cases due to its higher reproducibility[14,16] was based mainly on the ability for earlier bone loss detection than Periotest™ method. [16,19]

Nowaday, resonance frequency analysis has been introduced as a widely applicable clinical tool used for assessment of implant stability.[20] Furthermore, Zix et al. [14] reported the precise role of Osstell instrument over Periotest.

Based on such previously collected data, this study was directed to evaluate correlation between Periotest and Ostell as an implant stability measuring tools and the marginal bone level changes of immediately loaded implant used in two different bone qualities.

PATIENTS AND METHODS

Fourteen patients received sixteen single implants (Dentium implant system, South Korea) forming a uniform common pool of either posterior maxillary or mandibular single missing tooth. Then, patients were randomly divided into two equal, harmoniously distributed groups of posterior maxillary and mandibular region respectively. Patients were selected from outpatient clinic of Oral & Maxillofacial surgery department, Faculty of Dentistry, Mansoura University. All patients with systemic diseases, immunosuppressed; and those with bruxism or need for bone grafting procedures were excluded from this study.

Preoperative measures

After clinical examination, an impression was made using silicon rubber base material for working cast fabrication. Then, surgical drill guide was established. Preoperative digital panoramic radiographs (SCANORA- Finland- focal spot size0.5mm/ Exposure Time 17.6 second– Minimal total filtration 2.7mm) were taken for all patients to verify bone height and assuring that planned implantation site is free from any local pathological conditions.

For all patients included within both groups, Amoxicillin 500 mg (Emox, Egyptian Int. Pharmaceutical Industries Co., E.I.P.I.C.O., A.R.E.) was prescribed every 6 hours for two days preoperatively as a prophylactic antibiotic.

Surgical procedures

After local anesthesia administration (Mepivacaine HCL 2% with Levonordefrin 1:20,000. Alexandria Co. for Pharmaceuiticals and Chemical Ind. Alexandria. Egypt), a marginal gingival incision was made, and the mucoperiosteal flap was reflected (Fig.1-A). The drilling was done using a low speed, speed reduction, high-torque contra-angle with surgical motor unit (KaVo, INTRAsurg® 300. Germany).

Drilling was performed at 1000 rpm for posterior mandibular bone and 800 rpm for posterior maxillary bone at the accurate direction guided by the surgical drill guide. The externally irrigated drill was used for drilling. The implant was guided into its position with light stable finger pressure. The coupling wrench with ratchet was used to complete installation of the implant till the bone level (Fig.1-B). For each patient within both groups porcelain fused to metal crown was fabricated and temporarily seated within occlusion for 6 months to allow periodic assessment of implant stability (Fig1-C).

All patients included in this study were evaluated clinically for measuring implant stability and radiographically for assessment of marginal bone level changes either immediately or at 3 and 6 months.

Implant stability assessment

Implant stability was assessed using periotest (Periotest M, Medizintechnik Gulden, Germany).[21] The score was based on three grades according to the recorded periotest values (PTVs). Grade I: PTVs range from -08 to 0 indicating well integrated implant and pressure can be applied to it. Grade II: PTVs range from +1 to +9 revealing that pressure application on the implant is generally not (yet) possible. Grade III: PTVs range from +10 to +20 indicating insufficient osseointegration and pressure can not be applied on the implant.

The stability of the implant was measured through recording periotest values (PTVs) at different time intervals of follow up by applying the handpiece of the Periotest perpendicular to the abutment connection to reduce operatoer errors, depending on the site of measurement.[21]

For resonance frequency analysis, Smartpeg (Osstell AB Stampgatan 14-SE 41101, Göteborg, Sweden) was attached to the fixture and the implant stability quotient (ISQ) value was obtained from the Osstell Mentor.[22] Both of Periotest and Osstell values were measured by same operator to minimize the possibility of recording errors.

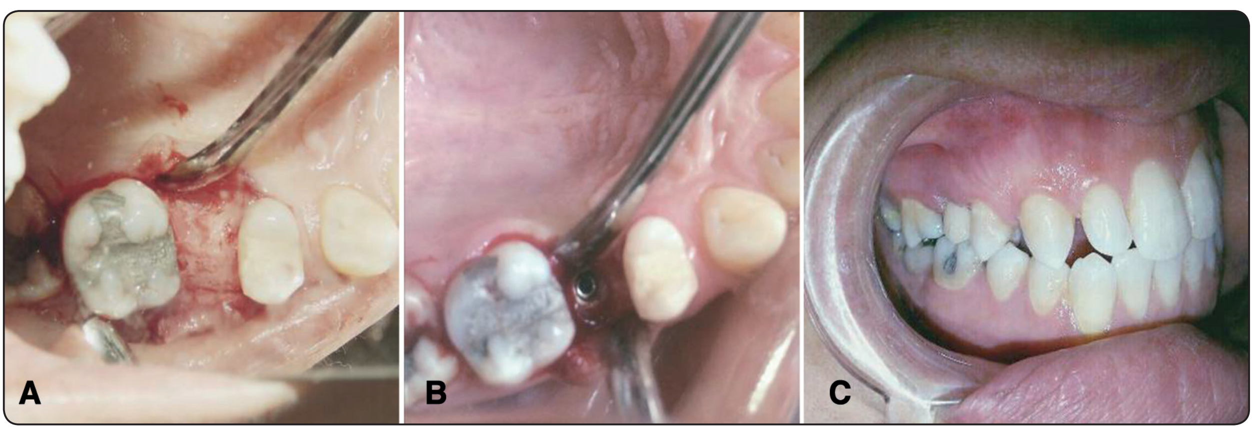

Fig. (1-A) A photograph revealing flap reflection in the site of the maxillary right 2^{nd} premolar 1-B After fixture installation 1-C An intra oral lateral view after crown attachment with temporary cementation,

Radiographic Evaluation

Marginal bone level changes either immediately or at 3, 6 months were evaluated by standard digital panoramic radiographs. The radiographs were scanned with a negative scanner then opened by Adobe Photoshop CS3 program. A horizontal line was drawn at the neck of implant on the immediate postoperative panoramic x-ray. The mesial and distal vertical distances between the horizontal line and the crestal bone levels were recorded to determine the initial crestal bone level around the implant. The mesial and distal vertical bone loss between horizontal line and the lowest marginal bone level were evaluated either at 3 or 6 months. The highest difference between the mesial and distal site was selected to establish the mean vertical bone loss (Fig. 2).[23]

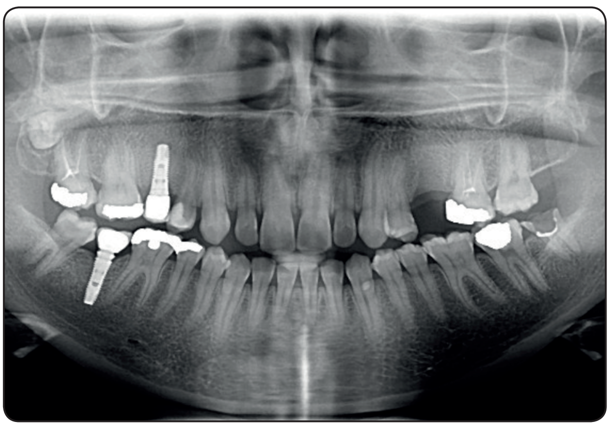

Fig. (2) Showing a postoperative panoramic radiograph revealing marginal bone level changes around two single implants intstalled in posterior maxilla & mandible after 6 months of immediate loading.

Microsoft Office Excel 2007 program and Statistical Package for Social Science (SPSS) version 16 was applied for data analysis. The description of the data was done in form of mean (+/-) SD for quantitative analysis by t test to compare both groups. The Bivariate Correlations procedure was used to compute Pearson's correlation coefficient with its significant levels between both groups and within each group among variables.

RESULTS

Fourteen patients, 3 males and 11 females with an average mean of age 27 years (range 20 to 50) received sixteen implants, were included in this study according to criteria for replacement of a single maxillary and mandibular posterior tooth. Six first premolars, five second premolars, and five first molars replaced. The distribution of implant diameters used in this study were 3.6mm (68.75%), 4mm (31.25%) with a common implant length 12mm (100%).

All patients were subjected to immediate loading of dental implants. The patients were harmoniously and equally divided into two groups according to bone quality included in this study. All patients received temporary cementation of porcelain fused to metal crown restoration during the initial postoperative 6 months. All patients included in this study were subjected to clinical assessment of implant stability using periotest and Ostell and radiographically for assessment of marginal bone level changes at 3 and 6 months respectively.

Assessment of marginal bone level

In the 1st group, 3 months after implant insertion the mean (MBL)was 0.485mm ±.063. While, after 6 months the mean (MBL) was 1.22 mm ±.092. In the 2nd group, 3 months after implant insertion the mean (MBL) was 0.618mm ±.079. While, after 6 months the mean (MBL) was 0.918 mm ±.171 (Table 1).

Regarding to the (MBL), a statistical difference was recorded between both groups at the different times intervals of follow up either at 3 or 6 months respectively (P= 0.000). In both groups, there was statistical significant difference when comparing the (MBL) values obtained at 3 months with that recorded at 6 months either within maxilla or mandible respectively (P=0.015- 0.005) (Table 2).

Implant stability assessment

Considering implant stability assessment using periotest, in the 1st group immediately after implant installation the mean periotest values (PTVs) was-4± 0.185 compared with mean (PTVs) -3.7±0.169 recorded within 2nd group. After 3 months from implant insertion in 1st group the mean (PTVs) was -4.3± 0.151 compared with mean (PTVs) -3.40 ±.169 recorded within 2nd group. While, after 6 months the mean (PTVs) was -4.2± 0.213 compared with mean (PTVs) -3.42 ±.0205 recorded within 2nd group (Table1).

Regarding to the collected PTVs used for evaluation of implant stability, a statistical difference was recorded between both groups at the different time intervals of follow up either at 3 or 6 months respectively (P= 0.000). In both groups, there was no statistical significant difference when comparing the PTVs values obtained at 3 months with that recorded at 6 months either within maxilla or mandible respectively (P= 0.516- 0.316) (Table 2).

Considering implant stability assessment using ostell, in the 1st group immediately after implant installation the ISQ values were ranged from 55-58 compared with ISQ values ranged from 63-65 recorded within 2nd group. After 3 months from implant insertion in 1st group the mean ISQ values was 59 ±0.755 compared with mean ISQ values 65± 1.72 recorded within 2nd group. While, after 6 months the mean ISQ values was 61 ± 1.19 compared with mean ISQ values 65± 1.51 recorded within 2nd group (Table 2).

Regarding to the collected ISQ values used for evaluation of implant stability, a statistical difference was recorded between both groups at the different times of follow up either at 3 or 6 months respectively (P= 0.000). In both groups, there was no statistical significant difference when comparing the ISQ values obtained at 3 months with that recorded at 6 months within posterior mandible (P=0.111). Additionally, there was no statistical significant difference when comparing the ISQ values obtained immediately after implant installation compared with that recorded at 6 months within posterior mandible (P=0.111). However, a statistical significant difference was recorded when comparing the ISQ values obtained at 3 months with that recorded at 6 months within posterior maxilla (P=0.000) (Table 3).

In posterior mandible, a positive significant correlation was revealed among PTVs and ISQ values obtained after 3 months of loading (P=0.003). Whereas, such positive significant correlation was remarked between PTVs and ISQ values obtained after 6 months of loading in posterior maxilla (P=0.004) (Table 3). In posterior maxilla, a positive significant correlation was established between PTVs and MBL recorded after 3 months (P=0.036). Such findings was inversely changed into a negative significant correlation between PTVs and MBL after 6 months in 2nd group (P=0.02).

TABLE (1) Showing mean and standard deviation of MBL, Periotest and ISQ values of both groups at different time intervals of follow up.

Bone Type/ Parameter	Posterior Maxilla				Posterior Mandible			
	3 month		6 month		3 month		6 month	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
MBL	0.485	0.639	1.225	0.0925	0.6188	0.0799	0.9187	0.171
PTV	-4.30	0.1511	-4.20	0.213	-3.40	0.1690	-3.42	0.205
ISQ	59	0.755	61	1.195	65	1.726	65	1.511

TABLE (2) Showing inter & intra-group comparison of MBL, periotest and ISQ values at different time intervals of follow up.

Bone Type/ Parameter	Posterior Maxilla	Posterior Mandible	Post-Max Vs Post-Mand	Post-Max Vs Post-Mand
	3months Vs 6months	3months Vs 6months	3months Vs 3months	6months Vs 6months
MBL	0.000	0.010	0.015	0.005
PTV	0.516	0.316	0.000	0.000
ISQ	0.000	0.111	0.000	0.000

TABLE (3) Showing inter-groups Person Correlation between periotest and ISQ values and level of significance at different time intervals of follow up.

Bone Type/ Time Interval	Posterior Maxilla			Posterior Mandible		
	ISQ Vs PTVs			ISQ Vs PTVs		
	Person correlation	n	P value	Person correlation	N	P value
3 months	-0.438	8	0.278	0.894	8	0.003
6 months	0.884	8	0.004	0.644	8	0.085

DISCUSSION

Controversial debate is continued about development of non invasive but sensitive, accurately reflecting tool reveals the remodeling changes at the bone-implant interface especially, in the early phases of osseointegration of different bone qualities. Additionally, applying immediate load has been used in this study to evaluate which of the two most commonly used devices either Periotest or Ostell has the capability to declare to clinicians the changes occurred in the bone-implant interface. Such declaration can represent a pivotal point in selecting which loading protocol should the clinicians follow.

Although, each implant stability device differs basically regarding their technical design, both methods were able to be used in the long-term follow-up of osseointegrated dental implant.[24] Many studies have represented RFA to be a predictable and reliable indicator of implant stability and success. [25,26] However, the optimal ISQ threshold values used to differentiate between implant success or failure has not been establised. [27]

Östman et al.[28] reported low failure rates among both edentulous jaws when ISQ value was > 60 in immediate loading protocol compared with better outcomes for same loading pattern with ISQ values higher than 65. While, low ISQ values indicate overloads or failures. Additionally, a previous study have shown a 99% survival rate of implants whose ISQ values exceed 65 at the time of implant placement.[29] Furthermore, many studies declared that ISQ values ranged between 60-65 can be considered as a cut off threshold required for implant success.[27,28,30]

In this study, the recorded ISQ values were compatible within this thersold and the lowest ISQ values were belonging implants installed within posterior maxilla after 3months of follow up only (ISQ=59). However, such finding can be supported by micro-CT study[31] revealed a lack of correlation between the ISQ values recorded at the time of implant placement and the bone density of the parent jawbone since the ISQ values were reduced slightly after 2–4 weeks and increased later on to the levels recorded at time of implant insertion or even higher.[31]

Furthermore, osseointegration in soft bone sites often based on maintaining primary anchorage that usually progress by time secondary to new bone formation rather than creating increased stability. So, immediate function can be considered as a viable option.[1]

Regarding to collected PTVs and ISQ values used for evaluation of implant stability, a statistical significant differences were recorded between both groups at the different time intervals of follow up either at 3 or 6 months respectively (P= 0.000). However, in both groups, there were no statistical significant differences when comparing the PTVs values obtained at 3 months versus that recorded at 6 months either within maxilla or mandible respectively (P=0.516-0.316) and only within posterior mandible during comparing the ISQ values obtained at same time interval (P=0.111). While, it became statistically significant within posterior maxilla for the same time interval of follow up (P=0.000).

In accordance with our findings, Huang et al.[32] reported a remarkable decrease of calculated frequency with low bone quality around implants. Additionally, Friberg et al.[33] reported the correlation between bone quality and implant stability by using two different stability measuring tool either cutting torque and RFA values during implant placement. It has been attributed to the fact that cortical bone is 10 to 20 times stiffer than the trabecular bone.[34]

In posterior mandible, a positive significant correlation was revealed between PTVs and ISQ values obtained after 3 months of loading (P=0.003) Whereas, such positive significant correlation was remarked between PTVs and ISQ values obtained after 6 months of loading in posterior maxilla (P=0.004).

Throughout reviewing the literature such variation in the findings of this study can be based on several clinical studies.[35-37] Tricio et al in 1995 have declared the inverse correlation between bone quality and PTVs.[35] Furthermore, association between bone density and PTVs was documented with the lowest PTVs reported within type 1 bone quality.[35]

Controversial results among authors about relationship between bone quality and the obtained ISQ values were varied from minimal importance [38,39] versus others revealed significant correlation.[34] Moreover, Barewal et al.[40] revealed that such relationship was restricted only to bone types 1 and 4. Other studies investigated the impact of implantation time,[41] bone density,[42] bone grafting and mechanical loading pattern[43] on ISQ values and demonstrated a significant relationship between ISQ values and either single and/or such factors.

Additionally, several studies stated that both techniques are suitable to detect a decrease in implant stability.[15,16] However, our results declared in 2nd group, a positive significant correlation between PTVs and MBL recorded after 3 months (P=0.036). Such findings was inversely changed into a negative significant correlation between PTVs and MBL after 6 months in 2nd group (P=0.02). Such findings can be attributed to absence of the linear correlation between PTV and the degree of bone density[36,37] in addition to increase in bone loss in posterior maxilla compared with posterior mandible especially, when subjected to immediate loading pattern.

Finally, analyzing our findings clarified that both of implant stability measurement tools revealed a variable individual responses between each other mainly during detecting earlier changes that affected seriously by bone quality especially, during the different marginal bone remodeling phases.

CONCLUSION

Posterior mandibular bone revealed an early positive significant correlation between PTVs and ISQ in comparison with posterior maxilla. Additionally, an early positive significant correlation has been established between PTVs and MBL in maxilla.

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