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A One-Year Retrospective Radiographic Assessment of Marginal Bone Loss Around Basal Implants and Impact of Multiple Risk Factors using Multivariate Analysis.

Evaluación radiográfica retrospectiva de un año de la pérdida ósea marginal alrededor de los implantes basales y el impacto de múltiples factores de riesgo mediante análisis multivariado.

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Abstract: Background: Factors like medical and periodontal conditions, implant location and smoking can affect marginal bone loss (MBL) of basal implants. Objectives: The purpose of this study is to explore the association of MBL with multiple variables including gender, age, smoking status, diabetes, implant placement protocol, location of implant, and type of prosthesis. Material and Methods: A total of 156 single-piece basal implants (Dr. Ihde Dental AG in Gommiswald, Switzerland) were placed in 44 patients. Dental panoramic tomographs were obtained postoperatively and following a one-year of service to determine MBL on mesial and distal sides. The association of MBL with the multiple variables was analysed using the multivariate and the random forest analysis. Results: The mean mesial and distal MBL was 0.64 millimetres. None of the implants presented MBL exceeding 1 millimetre. All implants were retained without complications during the first year of service. The MBL was remarkably associated with the smoking status, diabetes, location of implant and implant placement protocol. Diabetes mellitus is the most vital parameter in predicting MBL. Conclusion: The mean MBL of all implants did not exceed the threshold of 1 millimetre during the first year of service. When placing implants in patients who smoke and have diabetes, care should be taken.

Keywords: *dental implants; dental implantation, endosseous; basal bone loss; radiography, panoramic; immediate dental implant loading; risk factors.*

Resumen: Antecedentes: Factores como las condiciones médicas y periodontales, la ubicación del implante y el tabaquismo pueden afectar la pérdida marginal de hueso (PMH) de los implantes basales. Objetivo: La finalidad de este estudio es explorar la asociación de PMH con múltiples variables, incluido el sexo, la edad, el tabaquismo, la diabetes, el protocolo de colocación del implante, la ubicación del implante y el tipo de prótesis. Material y Métodos: Se colocaron 156 implantes basales de una sola pieza (Dr.Ihde Dental AG, Gommiswald, Suiza) en 44 pacientes. Se obtuvieron tomografías panorámicas dentales después de la operación y después de un año de servicio para determinar la MBL en los lados

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mesial y distal. La asociación de la PMH con las múltiples variables se analizó mediante el análisis multivariado y de bosque aleatorio. **Resultados:** La PMH media mesial y distal fue de 0,64 milímetros. Ninguno de los implantes presentó PMH superior a 1 milímetro. Todos los implantes se mantuvieron sin complicaciones durante el primer año de servicio. La PMH se asoció notablemente con el tabaquismo, la diabetes, la ubicación del implante y el protocolo de colocación del implante. La diabetes mellitus es el parámetro más importante para predecir la MBL. **Conclusion:** La PMH media de todos los implantes no superó el umbral de 1 milímetro durante el primer año de servicio. Se debe tener especial cuidado al colocar implantes en pacientes que fuman y tienen diabetes.

Palabras Clave: *implantes dentales; implantación dental endoósea; pérdida de hueso basal; radiografía panorámica; immediate dental implant loading; factores de riesgo.*

INTRODUCTION.

A series of molecular and cellular processes is initiated after the osteotomy of the implant site. These processes result in the biological integration of the host's native bony structure with the alloplastic material. Despite all efforts, marginal bone loss (MBL) still occurs in all types of implant, and this condition is prominent during the first year and continues during the subsequent years of service.[1]

The proper integration of bone and MBL after implant placement is affected by multiple factors, such as occlusal loading, smoking and diabetes mellitus.[2-4] The requirement for implant success is MBL less than 1 millimetre during the 1st year of service, with 0.2 millimetres in the following.[5]

Immediate implant placement following atraumatic extraction can result in the preservation of the soft and hard tissue dimensions of the alveolar ridge.[6] This clinical practice of immediate implant placement is becoming a more common therapeutic approach over the staged surgical protocol.[1] Another widely practiced clinical therapeutic approach is immediate implant loading with a reported success rate of 70.8% to 100%.[7,8]

When the natural teeth are extracted, the residual alveolar bone resorbs and recedes gradually, leaving the basal bone. This basal bone is not prone to resorption and infections like alveolar bone. The basal implant system utilises the basal cortical portion remaining following the tooth loss and the alveolar process of resorption of jaw bones.

The good quality of the cortical bone can provide sufficient retention and support for these implants as it is highly dense, corticated, and offers excellent support to implants. Basal implants, which are also called orthopaedic implants, have a special design to accommodate such implant fields and permit immediate loading of artificial teeth.[9]

In this retrospective study, single piece basal implants were used (BCS, IHDE Dental Implant System, Dr. Ihde Dental AG, Switzerland). Those implants consist of three parts: abutment, shaft, and bi-cortical screw. The abutment portions can be conical straight, conical angled or multi-unit abutments.

The bi-cortical screw is designed specifically to engage the buccal and the lingual/facial cortical plate and initially provide primary stability and load bearing capacity to the implant and later on act as a load bearing and distribution component. In regards to the implant surface treatment, all portions of the basal implant are machine polished to reduce inflammatory reactions post placement.[10]

This retrospective study was conducted with the aim to explore the MBL around basal-implants and its association with multiple independent parameters.

MATERIALS AND METHODS.

Patient selection

Medical and dental histories with complete dental examinations were obtained for all patients.

Patients with uncontrolled medical conditions or with active periodontal disease were excluded.

Patients who smoked were asked to stop smoking two weeks before and after implant placement. Informed consent was obtained from all patients before initiation of treatment.

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Surgical Protocol

A total of 156 implants (BCS, IHDE Dental Implant System, Dr. Ihde Dental AG, Switzerland) were inserted in 44 patients of Iraqi origin (equal gender distribution) aged 20 – 78 years.

Single-piece basal implants were inserted by the same oral and maxillofacial (OMF) surgeon following a consistent surgical protocol. All implants were placed at the College of Dentistry of Misan University. The size and the location of the implant were based on the assessment by preoperative Dental Panoramic Tomography (DPT, MyRay, Italy) and study models.

The size of implants ranged from 17 mm - 23 mm for the length and 3.5 mm -4.5 mm for the width. Local anaesthesia (2% lidocaine with 1:80,000 adrenaline) was administered using the local infiltration technique. The implant location was identified, and a transmucosal puncture incision was made using a pilot drill by utilising a modified flapless approach. After finishing the osteotomy, the one-piece basal implants were inserted, and primary stability was assessed using the insertion torque.

Implant Restoration

Whilst the local anaesthesia was still active, restorative treatment was initiated immediately after implant placement. A definitive impression was obtained using polyvinyl siloxane impression material (President dental, Allershausen, Germany). For partial and complete fixed bridges, the metal framework was sent for try-in the next day of implant placement.

The fixed porcelain fused to metal prostheses was fabricated and cemented after 3–5 days of implant placement. The occlusion was designed on the basis of Kim *et al.*,[11] occlusal guideline for implant therapy. The patients were assessed after 1 week and at 1, 3, 6 and 12 months.

Radiographic Assessment Protocol

Prior to analysis of the radiographs, one examiner (YA) was calibrated for measurement of bone loss. Twenty DPTs were chosen and bone loss was measured. The measurements were repeated after one day and an Intraclass Correlation Test (ICC) was conducted. The average ICC results were 0.899 and 0.910 for mesial and distal sides, indicating good to excellent reliability of the examiner in measuring the MBL.[12]

A preoperative DPT was obtained to assess bone availability. Another DPT was conducted postoperatively. A third DPT was obtained after one year of implant placement. The preoperative and the postoperative radiographs were collected using the same radiographic machine and the same bite jig to ensure parallelism and standardisation.

A blind examiner measured bone height from the bone-to-implant level to a fixed reference point by using digital magnification. The measurement was repeated twice at the distal and the mesial sides of each implant and the mean was calculated.

Data Analysis

The mean and standard deviation of MBL were calculated for each independent parameter. Multivariate analysis was made to assess the asso-ciation of bone loss by using the following parameters: gender, age, location of the implant (anterior and posterior maxilla, anterior and posterior mandible), type of prosthesis (single crown, partial fixed bridge, full arch fixed bridge), medical condition, smoking status, implant placement protocol (delayed, immediate). Random forest Analysis (RFA) was also conducted to assess the parameter that contributes the most to MBL.

Data was analysed using SPSS 23.0 (*https://www.ibm.com/analytics/spss-statistics-software*) and Spyder Python 3.7 software (https://www.spyder-ide.org/). Prior to the analysis, the skewness and kurtosis of mesial and distal MBL were assessed to confirm the normality of distribution.

RESULTS.

Descriptive analysis

Skewness and kurtosis analysis indicated that data was normally distributed. Additionally, no multicollinearity was found amongst the independent variables. A general descriptive statistic is presented in Table 1 and Table 2.

The mean mesial and distal MBL was 0.64 millimetres. None of the implants presented an MBL exceeding 1 millimetre. All implants were retained

Table 1. The marginal bone loss (MBL) following a one-year follow-up.

Statistics	Mesial MBL (mm)	Distal MBL (mm)
Mean	0.64	0.64
Median	0.62	0.64
Maximum	0.99	0.95
Minimum	0.42	0.41

Table 2. The mean Marginal Bone Loss (MBL) according to each considered parameter.

Independent Variables	Groups	n	Mesial MBL Mean ± SD (mm)	Distal MBL Mean ± SD (mm)
Gender	Male	22	0.76 ± 0.11	0.76 ± 0.10
	Female	22	0.55 ± 0.11	0.56 ± 0.11
Implant location	Anterior Maxilla	64	0.70 ± 0.13	0.70 ± 0.12
	Anterior Mandible	6	0.57 ± 0.15	0.59 ± 0.14
	Posterior Maxilla	54	0.61 ± 0.15	0.62 ± 0.15
	Posterior Mandible	32	0.57 ± 0.16	0.57 ± 0.15
Prosthesis type	Single Crown	21	0.64 ± 0.16	0.65 ± 0.15
	Partial Bridge	28	0.64 ± 0.16	0.65 ± 0.15
	Complete denture	10	0.61 ± 0.11	0.63 ± 0.10
Smoking status	Yes	14	0.79 ± 0.09	0.80 ± 0.08
	No	30	0.55 ± 0.11	0.56 ± 0.10
Diabetes mellitus	Yes	7	0.83 ± 0.05	0.83 ± 0.06
	No	37	0.58 ± 0.12	0.59 ± 0.12
Implant placement protocol	Immediate	33	0.84 ± 0.06	0.83 ± 0.05
	Delayed	123	0.58 ± 0.12	0.59 ± 0.12

SD: Standard deviation.

Table 3. The general linear model of Marginal Bone Loss (MBL) according to each considered parameter.

Independent Variables	Mesial MBL			Distal MBL		
	B	Standard error	*p*-value	B	Standard error	*p*-value
Gender	0.02	0.03	0.42	0.01	0.03	0.72
Implant location	−0.03	0.01	0.000	−0.03	0.01	0.000
Prosthesis type	0.02	0.01	0.11	0.02	0.01	0.08
Smoking status	−0.13	0.03	0.000	−0.14	0.03	0.000
Diabetes mellitus	−0.14	0.03	0.000	−0.12	0.03	0.000
Implant placement protocol	−0.09	0.02	0.000	−0.07	0.02	0.004
Age	0.00	0.00	0.61	0.00	0.00	0.93

Table 4. Random forest analysis (RFA) of Marginal Bone Loss (MBL) according to each considered parameter.

Parameter	Importance	
	Mesial MBL	Distal MBL
Diabetes mellitus	0.26	0.25
Implant placement protocol	0.21	0.19
Smoking status	0.17	0.19
Age	0.17	0.17
Gender	0.07	0.09
Implant location	0.07	0.06
Prosthesis type	0.05	0.05

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without complications during the first year of service (Table 1 and Table 2).

Multivariate Analysis

This analysis showed a statistically significant association of bone loss with implant location (p<0.001), smoking status (p<0.001), diabetes mellitus (p<0.001) and implant placement protocol (p<0.05). In contrast, the association of bone loss with the gender and age of patients was non-significant (p>0.05) (Table 3).

Random Forest Analysis

Data was analysed using the RFA to assess the parameter that contributes most to MBL. Results indicated that diabetes mellitus, implant placement protocol and smoking are the most critical parameters in MBL (Table 4).

DISCUSSION.

A considerable amount of evidence links diabetes mellitus to periodontal disease.[13,14] Individuals with diabetes are twice more likely to develop periodontal disease than healthy individuals. Several studies have evaluated the relationship of diabetes mellitus and the survival rate of implant treatment. Morris *et al.*,[15] compared the failure rate of implants in patients with diabetes and healthy individuals and found that the failure rate varies slightly whereas a significant MBL was reported for those with diabetes.

Alsaadi *et al.*,[16] have conducted a multivariate analysis and found that diabetes mellitus is not related to late implant loss. Moy *et al.*,[17] found a marked difference in the failure rate between patients with diabetes (14%) and patients without diabetes (4%). In this study, the multivariate analysis has indicated that MBL in patients with diabetes is significantly higher than those without diabetes.

However, the MBL is still less than 1 millimetre. Thus, the implant condition is not considered a failure and none of the implants was lost in the first year of service.

Smoking is related to the impairment of innate and adaptive immune systems and the reduction of vascularisation and blood flow in the gingiva.[18,19] Thus, smoking can impair the inflammatory response and wound healing postoperatively. Multiple studies have related implant failure to smoking.

Renvert *et al.*,[20] reported that tobacco users have a 35%–70% higher risk of implant failure than non-tobacco users. Penarrocha *et al.*,[21] reported that patients who smoke 10–20 cigarettes per day presented with significant MBL. The multivariate analysis in this study has indicated that the MBL is significantly associated with the tobacco-usage status of the patients. However, the number of cigarettes consumed daily is not considered in this study. The implant location affects MBL. Penarrocha *et al.*,[21] had reported significantly higher MBL in maxillary implants compared to mandibular implants. Calvo-Guirado *et al.*,[1] reported that MBL in the posterior maxilla is higher than that in the anterior maxilla. In this study, the bone loss is significantly asso-ciated with implant location and is higher in the anterior maxilla than in other locations.

Such a variation between studies could be explained by the variation in the smoking habit including smoking type and frequency. In a 5-year study, it has been found that MBL is significantly associated with gender.[1] However, this is in disagreement with the finding of the current study which used a one-year follow-up period. A short follow-up period may be not enough to elucidate gender differences. Regarding patient age, our finding is consistent with the finding of Penarrocha et al. where MBL was not significantly associated with the age of the patient at the time of implant placement.[21]

Dalago *et al.*,[22] showed that the association between the type of prosthesis and MBL is statistically significant.These results are not in agreement with those obtained in this study, which may be because of the difference in occlusal guidance or in the ethnicity and culture of the included subjects. The RFA analysis was used in this study to assess the parameters that caused the patient to be in the risk zone (approxing 1 mm of MBL). Diabetes mellitus is the most critical parameter followed by implant placement protocol and smoking.

Age is also highly important but is not correlated with MBL. As far as the authors' knowledge, no

article was found to use the RFA analysis for assessment of MBL.

Limitations of the Study

The duration of the study is short which limits the viability and accuracy of obtained results. Despite that, the results obtained are promising, long term studies are required to evaluate success and survival of basal implants compared to conventional implants.

CONCLUSION.

The significance of the association of MBL with multiple risk factors was investigated using the multivariate and the RFA analyses. Within one year of service, the MBL of all implants did not exceed 1 mm with a mean of 0.64 mm mesially and distally.

Multivariate analysis showed that MBL is significantly associated with implant location, smoking status, diabetes mellitus, and placement protocol. RFA analysis showed that diabetes mellitus is the most vital parameter in the prediction of MBL followed by smoking and placement protocol.

Conflict of interests: The authors want to declare that there is no potential conflict of interest.

Ethics approval: Informed consent was obtained from patients.

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