Clinical and radiographic evaluation of implant-supported mandibular overdentures subjected to immediate loading. A 36-month follow-up

Evaluación clínica y radiográfica de implantes rehabilitados con sobredentaduras mandibulares y sometidos a carga inmediata. 36 meses de observación

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Keywords: edentulous maxilla, implants, osseointegration, peri-implantitis, edentulous jaw, bone resorption

ABSTRACT

Introduction: the aim of this study was to clinically and radiographically evaluate 54 implant-supported mandibular overdentures under the protocol of immediate loading, using a retention system with ball attachments. This evaluation was performed within 36 months of function of the implants. ***Methods:*** observational descriptive study in 27 fully edentulous patients who were evaluated in a 36-months follow-up period, after having two internal connection implants placed in the interforaminal area of the lower maxilla. The implants were evaluated in terms of survival rate, amount of peri-implant bone loss, condition of peri-implant tissues, prosthesis behavior, and degree of patient satisfaction. ***Results:*** survival rate at 36 months was 98.1% and the average radiographic bone loss was 0.45 mm (SD 0.6); there was a low level of plaque and average probing depth was 1.75 ± 0.75 mm. 57% of prosthesis showed active retention. 43% did not show retention or it was provided by one of its elements. 53.8% of overdentures were stable. A high percentage of patients showed total satisfaction. ***Conclusion:*** in a 36-months follow-up, a mandibular overdenture with ball attachments placed on two non-splinted implants immediately loaded is a predictable treatment in patients with fully edentulous lower maxilla, with high implant survival rates, low levels of peri-implant bone loss, and a high degree of patient satisfaction.

Palabras clave: maxilares ed ntulos, implantes, seointegraci n, periimplantitis, mand bula ed ntula, reabsorci n sea.

RESUMEN

Introducci n: el objetivo de este estudio consisti en evaluar cl nica y radiogr ficamente, despu s de 36 meses de funci n, 54 implantes colocados en el maxilar inferior y rehabilitados con sobredentaduras bajo el protocolo de carga inmediata, utilizando un sistema de retenci n tipo bola. ***M todos:*** estudio observacional descriptivo que consider 27 pacientes totalmente desdentados que fueron evaluados en un seguimiento a 36 meses, luego de haber recibido cada uno dos implantes de conexi n interna, instalados en la regi n interforaminal del maxilar inferior. Los implantes fueron evaluados en t rminos de supervivencia, cantidad de p rdida sea periimplantar, estado de los tejidos periimplantares, comportamiento de la pr tesis y grado de satisfacci n de los pacientes. ***Resultados:*** la tasa de supervivencia a los 36 meses fue de 98,1%, el promedio de p rdida sea radiogr fica fue de 0,45 mm (DE 0,6); se present un nivel de placa bajo y el promedio de profundidad al sondaje fue de 1,75 ± 0,75 mm. El 57% de las pr tesis presentaron retenci n activa. El 43% no present retenci n, o su retenci n estaba dada por uno solo de sus elementos. El 53,8% de las sobredentaduras se encontraron estables. Un alto porcentaje de los pacientes manifestaron satisfacci n total. ***Conclusi n:*** a 36 meses de observaci n, una sobredentadura mandibular retenida por pilares en bola colocada sobre dos implantes no ferulizados y cargados inmediatamente es un tratamiento predecible en pacientes con desdentaci n total inferior, con una alta tasa de supervivencia de los implantes, bajos niveles de p rdida sea periimplantar y alto grado de satisfacci n de los pacientes.

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INTRODUCTION

Implant-supported overdentures are currently an alternative treatment option for fully edentulous patients, especially in the lower maxilla; this type of overdentures significantly benefit patients with stability and retention problems using a conventional lower denture.[1] The initial protocols favored the use of four splinted implants with bars. However, some circumstances may hinder or contraindicate the use of a sufficient number of implants for definite rehabilitation, including severe bone resorption, unfavorable intermaxillary relations, anatomical limitations, low quantity and quality of bone in the receptor site,[2, 3] and financial reasons.[4]

In 2002, the McGill consensus suggested that mandibular two-implant overdentures should be the minimum treatment offered to patients with fully edentulous mandible.[5] Splinted and non-splinted systems are generally used to connect the implants to the overdenture. Several retention systems have been compared and there is no strong scientific evidence to suggest that one is better than the others.[6]

As a result of the advances in different implant systems and a greater understanding of the healing process, the original delayed loading protocol has been questioned and modified.[7] Recently, clinical research results have encouraged the progressive shortening of the healing period, and the immediate loading of implants has been proposed in the various restoration modalities, with high reported success rates.[8]

The aim of this study was to clinically and radiographically evaluate, after 36 months of placement, 54 implants placed in the interforaminal area and rehabilitated with overdentures under the protocol of immediate loading using a retention system with ball attachments.

MATERIALS AND METHODS

An observational descriptive study was conducted. The Universidad Aut noma de Manizales Bioethics Committee approved the research protocol by means of Act 12 of 2010. All patients filled an informed consent according to Resolution 8430 of Colombia's Ministry of Health.

The study started with a population of 30 patients. Each patient received two implants (Biohorizons® Taper Internal 3.8 x 15 or 3.8 x 12 mm) in the interforaminal area of the mandible, rehabilitated with a two implant-supported overdenture and individual ball attachments. Patients were systematically evaluated each year. In the 36-months follow-up period, two patients moved to another city and one was reported dead by his relatives. For these reasons, 27 overdentures and 54 implants were evaluated.

Using periapical radiography, a periodontist calibrated in image analysis software (Sopro Imaging) evaluated the crestal peri-implant bone. Measurements were made at 0, 12 and 24 months (T0, T1, T2). Radiographs were also evaluated to determine bone loss at 36 months (T3). To calculate bone loss, the researchers measured the distance from the implant platform to the most apical bone level in contact with the implant body on its mesial and distal surfaces. The distortion of each radiograph was calculated before making the measurements, considering the length of the implant in position. The amount of bone loss was determined by the difference between the two lengths for each implant, and the average of all implants was calculated.[9]

The implants' success rate was assessed using the criteria by Albrektsson and Zarb:[10] absence of persistent pain or dysesthesia, absence of peri-implant infection with

drainage, absence of mobility, and absence of peri-implant bone resorption greater than 1.5 mm during the first year of loading and 0.2 mm after the second year.

Bacterial plaque and bleeding were evaluated with the Mombelli indices.[11] The mesial, distal, buccal, and lingual surfaces of each implant were measured to obtain the modified bacterial plaque index. The score was calculated using the average obtained on the four surfaces, as follows: 0: no bacterial plaque detected; 1: bacterial plaque is detected only by passing the periodontal probe through the implant's marginal surface; 2: visible bacterial plaque; 3: abundant bacterial plaque. For the bleeding index, the mesial, distal, buccal, and lingual surfaces were measured. The score for each implant was calculated with the average of the four scores, as follows: 0: no bleeding when passing the periodontal probe around the gingival margin adjacent to the implant; 1: isolated bleeding spots; 2: presence of a confluent line of blood around the mucosa of the implant's margin; 3: heavy or profuse bleeding. Probing depth was defined as the average score of the measurements in four sites: mesial, distal, buccal, and lingual, using a calibrated periodontal probe (Hu-Fryde). The presence or absence of dental calculus was also measured.

The evaluation of prostheses was performed by an oral rehabilitator who participated in the research process since the beginning. This evaluation included aspects like retention, stability, presence or absence of fractures or fissures in the prosthesis, and the status of its retentive elements. Retention was considered acceptable if there was evidence of active retention at the time of application of the debonding force. This was assessed by applying a force in the opposite direction to the insertion pathway on the prosthesis and asking: does it remain in place? Stability was considered acceptable only if a minor movement was observed when the overdenture was manually subjected to moderate horizontal forces. It was also assessed by asking the patient: does it work when speaking? Static and dynamic occlusion was evaluated with articulating paper; it was considered acceptable when there was bilateral occlusal stability during the intercuspal position, with no interference during normal occlusion. It was also evaluated by asking: does it work when chewing? Fissures and fractures were assessed by direct observation. The retentive elements were observed to verify that they were intact and fulfilling their retentive role.

Patient satisfaction was assessed by applying the survey validated by Bergendal et al in 1998,[12] by means of a visual analogue scale that compares the overall prosthetic function before and after placing the implant and with the patient's impression on treatment outcome, which was evaluated with the following "yes"/"no" questionnaire: 1) Are you satisfied with your prosthesis? 2) Does it stay in place? 3) Does it work when chewing? 4) Does it work when speaking? 5) Is your prosthesis pretty?

Patient sociodemographic and implant data were recorded in IBM® SPSS 21.0. Data were analyzed with descriptive statistics, using measures of central tendency and variability for the quantitative variables. Qualitative analyses were done using absolute and relative frequencies. Groups comparisons were performed with Student's t-test between T0 and T1, T0 and T2. The chi-square test was used for the comparison grouped by qualitative variables. A $p < 0.05$ significance level was used.

RESULTS

Implant survival rate at 36 months was 98.1%, corresponding to 54 implants with successful characteristics. In the 36-months period, one of the 60 implants was lost during the first year (Table 1).

Table 1. Implant survival in the follow-up period

Time	No. of patients n	Evaluated implants n	Unsuccessful implants n	Survival rate %
0 months	30	60	0	100
12 months	29	57	1	98.1
24 months	28	56	0	98,1
36 months	27	54	0	98.1

Regarding peri-implant conditions, the statistical results showed that the average radiographic bone loss at three years was 0.45 mm (0.6 standard deviation). Table 2 shows that average bone loss in the third year is less than 1.0 mm.

The overall plaque index average was 0.48 (95%CI 0.22-0.70), which is interpreted as absence of plaque. 60.1% of implants had no plaque (score 0), there was no visible plaque in 33.2% of patients—only when instrumenting with a probe (score 1). 5.8% showed visible plaque (score 2) and 1.0% showed visible plaque around the implant (score 3). Plaque index in the right-side was higher (0.50) (95%CI 0.34-0.83) than in the left-side implants (0.45) (95%CI 0.23-0.72), but with no statistically significant differences (p = 0.65).

The overall bleeding index average in the peri-implant tissues was 0.24, distributed as follows: *right side:* level 0: 65%, level 1: 26.9%, level 2: 7.7%, level 3: 0%; *left side:* level 0: 58.8%, level 1: 38.5%, level 2: 7.7%, level 3: 0%. No statistically significant differences were found between the left side and the right side (p = 0.67).

Table 2. Average radiographic bone loss in the follow-up period (in mm)

Mesial right implant			Distal right implant			Mesial left implant			Distal left implant		
Baseline (95%CI)	1 Year (95%CI)	3 years (95%CI)	Baseline (95%CI)	1 year (95%CI)	3 years (95%CI)	Baseline (95%CI)	1 year (95%CI)	3 years (95%CI)	Baseline (95%CI)	1 year (95%CI)	3 years (95%CI)
0.32 (0.14-0.51)	0.54 (0.29-0.79)	0.59 (0.35-0.83)	0.44 (0.25-0.62)	0.81 (0.51-1.12)	0.90 (0.60-1.20)	0.32 (0.14-0.50)	0.82 (0.54-1.10)	0.89 (0.6-1.18)	0.29 (0.12-0.46)	0.66 (0.41-0.91)	0.71 (0.46-0.96)

Probing depth was 1.75 ± 0.75 mm. The surfaces with the greatest probing depth were the mesial ones, for both the implants on the right side (30.8%) and the left side (26.9%). Only 3 patients (11.5%) showed 0 mm of probing depth. Table 3 shows the frequency of probing depth per implant and zone. None of the 54 implants showed calcified plaque on any of the evaluated surfaces. The values for other conditions are listed in Table 4.

Table 3. Probing depth at 36 months. Frequencies are grouped by side and zone.

	Right				Left			
Probing depth	n	Mesial	n	Distal	n	Mesial	n	Distal
0 mm	3	11.5%	3	11.5%	3	11.5%	3	11.5%
1 mm	8	30.8%	5	19.2%	7	26.9%	5	19.2%
2 mm	7	26.9%	11	42.3%	9	34.6%	10	38.5%
3 mm	8	30.8%	7	26.9%	7	26.9%	7	26.9%

It was found that 57% of the prostheses had active retention and 43% did not show retention, or it was provided by one of their elements only. 53.8% were stable at the time of evaluation at 36 months and 46.2% were unstable. 100% of overdentures had adequate and stable occlusion with their antagonists. 11.5% of prostheses showed fissures on some points and 11.5% presented clinical evidence of fractures on some points. 76.9% of overdentures were intact at the time of clinical examination.

Table 4 describes other overdenture conditions observed in the clinical examination. It was clear that the most common needs are changing the retention elements (in 5 cases) and changing the attachment that provides retention to the prosthesis (in 4 cases).

Table 4. Other conditions of the state of overdentures

Observations	No. of cases	%
Need to change retentive elements (rubbers)	5	19.2
Need to change retention attachments (housing)	4	15.4
Need to repair incisal edge fractures	3	11.5
Need to rebase the prosthetic base	2	7.7
Pigmentations	2	7.7
Presence of calculus on prostheses	2	7.7

As for overall satisfaction, 100% of surveyed patients said they were satisfied with the prosthesis, 80.8% indicated that the prosthesis remains in place while functioning and 88.5% reported that the prosthesis works well when speaking. 96.2% considers that the prosthesis looks pretty.

DISCUSSION

Implant survival in this study with a 36-months follow-up was 98.1%. These results can be compared with those reported by Friberg et al in 1991,[13] Wagenberg in 2006,[14] Levin et al in 2006,[15] and Machtei et al in 2007,[16] with survival rates ranging from 96 to 100%. In 2014, Kronstrom et al[17] reported 100% survival rate during a prospective randomized study in one- and two-implant supported overdentures under the immediate loading protocol with a 3 years follow-up in 36 patients. Geckili et al, in 2011,[8] also reported a survival rate of 100% at 3 years in 27 patients rehabilitated with three-implant-supported overdentures using ball and bar retention systems immediately loaded.

A literature review conducted by Chrcanovic et al in 2014[18] concluded that bone quality of both receptor site and placement site influences implant survival rate. This fact is confirmed by the results of the study by Friberg et al in 1991,[13] who reported that 32% of failures occurred in soft bone sites. It can be then inferred that placement site influenced the implant survival rate in the present study (98%).

In a systematic review in 2012, Kim et al[19] evaluated the survival rate of mandibular overdentures in relation to the retention systems used, including ball retention systems. The results showed a survival rate of 96 to 100% for overdentures supported by two non-splinted implants with a ball retention system. These results are consistent with those of our study, where a ball retention system was used.

Primary stability is considered one of the most important clinical parameters for the immediate loading of implants,[20] as a prerequisite for the correct osseointegration of implants once in place.[20-22] The method established to evaluate primary stability consists of measuring the insertion torque once the implant has been placed in the prepared bed.[23] In 2012, Cannizzaro et al[24] reported a 100% success rate of implants inserted with torques greater than 35 N. On the other hand, a prospective comparative study conducted by Chiapasco et al in 2001[25] assessed mandibular overdentures on splinted implants under the immediate loading protocol, comparing it with delayed loading. The results showed no significant differences between both groups, with a survival rate of 95.7%. In our study, all the implants were placed with an insertion torque greater than 45 N and rehabilitated under the immediate loading protocol, obtaining a high survival rate, which agrees with the results of the aforementioned studies and highlights the benefits of immediate loading as a valid alternative to overcome the problems of conventional loading.

In recent years, biotechnology has made numerous efforts to improve osseointegration by modifying the surface properties of titanium, because that is where the early interaction between implant and surrounding tissues occurs once the implant has been placed.[26] Recent studies have suggested that surface-modified titanium shows a wide range of chemical and physical properties that favor both osseointegration and the survival of implants.[27, 28] Therefore, the high survival rate obtained in our study at 36 months can be associated with the characteristics of the implants used. According to the manufacturer (BioHorizons®), these features favor mechanical retention (primary stability) and maximum long-term bone maintenance, as demonstrated by peri-implant bone loss around implants at 36 months, which is consistent with the studies by Buser et al[29] and Heinemann et al,[30] who claim that the length, macro- and micromorphology and configuration of the nut or bolt are critical factors for an increased primary stability. The increase in surface topography increases surface area, allowing a bone-implant contact in a short time after placement.

Many studies have analyzed peri-implant bone loss to determine the amount of clinically acceptable bone loss. In 1986, Albrektsson et al[31] reported a loss of 0.2 mm annually after the first year. In 1990, Van-Steenberghe et al[32] pointed out that 1.0 mm bone loss is expected during the first year, depending on the implant, which even stabilizes in time. In our study, peri-implant bone loss at 36 months was 0.45 mm. In a retrospective study of 3 years conducted by Geckili et al in 2011[8] evaluating peri-implant bone loss in 23 patients rehabilitated with mandibular overdentures on 3 implants placed between the interforaminal zone, the reported overall bone loss between the two groups was 0.70 to 1.06 mm, with no statistically significant differences between both groups. In agreement with the data reported by Geckili et al;[8] in 2006, Ormianer et al[33] reported 1.0 mm bone loss after 2.5 years.

The peri-implant bone loss values obtained in this study (0.45 mm) remain below the ranges considered normal in the international literature: 1.0 mm in the first year and less than 0.2 mm per year.[32, 34, 35] It is important to note that the results in terms of peri-implant bone loss at 36 months may be associated with the type of retention system used (ball) for overdentures supported by two

implants and loaded immediately, and are comparable with the results of overdentures splintered by means of bars.

Lindquist et al in 1996[36] and Tang et al in 2000[37] identified inflammation and implant hygiene as critical factors for peri-implant bone loss; plaque index, gingival bleeding index, depth of bleeding, and the presence of calculus are the factors accepted worldwide for the evaluation of peri-implant tissues, since it is a reproducible method and allows comparisons with other studies. In 2016, Per ić et al[38] evaluated oral health to 3 years and the quality of life of 122 patients treated with three different types of mandibular overdentures. The results showed that the group of patients using overdentures with ball retention system had the lowest bacterial and gingival plaque index (0: 20%) when compared with bar and locator systems.

In evaluating the conditions of peri-implant tissues, the results of our study show an overall average of 0.48 bacterial plaque index. The bleeding values observed while measuring peri-implant depth showed an overall bleeding value of 24%, with 0 (not bleeding at probing depth) as the most predominant value in implants on both the right side and the left side, and no evidence of the presence of calcified plaque on any of the evaluated implants. On the contrary, N rhi et al, in 2001,[39] showed that the presence of plaque or peri-implant bleeding was not associated with the type of retentive element. Other studies do not establish a direct relation between bacterial plaque index, soft tissues complications, and early loss of implants.[39] These clinical findings suggest that the retention system influences the proper maintenance of peri-implant tissues because the patient can perform a better hygiene, compared with those patients using bar retention systems, and that the optimal biological conditions of the peri-implant tissues can be associated with the high survival rate found.

The evaluation of prosthesis stability and retention yielded values above 51% at 3 years of prosthesis in function. This demonstrates the great performance of ball retention systems, with a success rate of 100%, consistent with the reports by Davis et al in 1996.[40] In terms of function (speech and mastication), as well as mechanical (support, stability, and retention), psychosocial (safety, comfort, and self-esteem) and aesthetic aspects, this study showed that patients report a greater capacity for chewing foods of different consistency, as well as greater comfort and safety, which makes this type of treatment a cost-effective solution for the management of lower full edentulism, ratifying the reports of scientific evidence.[41]

A high percentage of patients showed satisfaction with their overdentures. Patient satisfaction is a factor influencing overdenture success.[42]

Similar results were obtained by Pocztaruk R et al,[43] with 95.83% patient satisfaction. Awad et al[44] reported that patients using two-implant supported mandibular overdentures showed a significant high percentage of satisfaction regarding various functional aspects of the prosthesis (stability, comfort, and masticatory capacity).

CONCLUSIONS

In the clinical and radiographic observation at 3 years, patients with full edentulous mandible treated with two implants and ball attachments placed in the mandibular area, immediately loaded and rehabilitated with overdentures, reported a high success

rate with no compromise of peri-implant tissues; they also expressed high levels of satisfaction with the implants. Despite the short observation period used in this study, it can be said that the procedure reduces prosthodontic rehabilitation time, without compromising the outcomes of the implants.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest.

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