COMPARISON OF IMMEDIATE VERSUS EARLY LOADED DENTAL IMPLANTS IN THE POSTERIOR MANDIBLE USING RESONANCE FREQUENCY ANALYSIS

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ABSTRACT

INTRODUCTION: The clinical measurement of implant stability and osseointegration is important to be able to assess success in implant dentistry. It is now possible to measure implant stability at any time during the course of implant treatment and loading.
OBJECTIVE: This study was designed to compare the implant stability of both the immediately and the early loaded dental implants in the posterior mandible by resonance frequency analysis using Osstell ISQ.
MATERIALS AND METHODS: Fourteen patients were included in this study (n=14). They were divided in two groups; group I (n=7) and group II (n=7). Group I**:** Seven patients having missing mandibular molars received an implant in the posterior mandible followed by immediate loading of provisional restoration (immediate loading). Group II**:** Seven patients having missing mandibular molars received an implant in the posterior mandible and the provisional restoration delivered one month post-insertion (early loading). All patients received dentium superline implant system with an SLA (sandblasted and acid etched) surface. Implant stability quotient (ISQ) was measured using resonance frequency analysis by the Osstell^{TM} device (Osstell Mentor) wireless device. The implant stability was measured immediately post-operative and on intervals of 1, 3 and 6 months.
RESULTS: The mean implant stability values in immediate and early loading immediately post-operatively was 69.0±10.71, 61.86±14.22 respectively. There was an increase after 3rd month to be 71.29±2.14, 75.86±3.18 respectively. The implant stability continued to increase after 6th month to be 71.29±4.61, 77.71±1.60 respectively. The increase in implant stability after 3rd and 6th month was statistically significant.
CONCLUSION: The mean implant stability quotient (ISQ) increased throughout the follow-up period.
KEY WORDS: implant stability, immediate loading, resonance frequency analysis.

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INTRODUCTION

General anesthesia (GA) is a medical procedure that Osseointegration has been used to define a direct structural and functional connection between ordered living bone and the surface of a load carrying implant (1).

The process of osseointegration involves an initial interlocking between alveolar bone and the implant body (primary implant stability), and a later, biological fixation through continuous bone apposition (contact osteogenesis) and remodeling toward the implant (secondary implant stability) (2).

Misch et al (3), suggested a terminology for immediate restoration and/or occlusal loading. The immediate occlusal-loading protocol is an implant-supported temporary or definitive restoration in occlusal contact within two weeks of the implant insertion. Early occlusal loading refers to an implant-supported restoration in occlusion between 2 weeks and 3 months after implant placement. Delayed or staged occlusal loading refers to an implant prosthesis with an occlusal load after more than 3 months after implant insertion.

Originally, the protocol described by Brånemark and associates (4,5) for direct bone-to-implant contact used submerged unloaded implants. More recently, many researchers, including Brånemark et al (6), have revealed comparable results for the integration of implants placed under immediate functional load. In many clinical situations,
it is beneficial to the patient to use the immediate loading protocol rather than the conventional 2-stage protocol, as the former allows the patient to have a functional fixed prosthesis the same day as implant placement (6-13).

The clinical measurement of implant stability and osseointegration is important to be able to assess success in implant dentistry. It is now possible to measure implant stability at any time during the course of implant treatment and loading (14).

There are some traditional methods including histological and histomorphometric observations, removal torque analysis percussion tests, pull-and push-through tests, and Periotest to evaluate the initial bone quality and degree of osseointegration (15-17).

In 1996, Meredith et al (14), developed a non-invasive and non-destructive method to evaluate the condition of the implant–tissue interface; it was called (resonance frequency analysis) (RFA). The use of RFA provides a possibility to clinically measure implant stability and osseointegration.

Resonance frequency values ranging from 3,500 to 8,500 Hz are translated into an implant stability quotient (ISQ) of 0 to 100. A high value indicates greater stability, whereas a low value implies instability. The manufacturer's guidelines suggest that successful implant typically has an ISQ greater than 65. An ISQ < 50 may indicate potential failure or increased risk of failure (18).

Today the Osstell™ has been updated with a new version called Mentor (Integration Diagnostics) that, while maintaining the ISQ scale, features wireless transducers that are electromagnetically excited (19-21).

Jaramillo et al. in 2014 (22) reported that Resonance frequency analysis systems in Osstell Mentor and Osstell ISQ show almost perfect reproducibility, repeatability and accuracy.

The resonance frequency analysis technique may be useful for assessing immediate loading implants during the various stages of treatment. For instance, a certain implant stability quotient value can be used as an inclusion criterion for immediate loading of implants. ***Ostman et al.*** (23,24), reported low failure rates when using implant stability quotient 60 as an inclusion criterion for immediate loaded implants in totally edentulous maxillae and in posterior mandibles. Values above implant stability quotient 65 indicate a favorable response to immediate loading, whilst low implant stability quotient values may be indicative of overload and ongoing failure.

The present clinical study was conducted to evaluate the implant stability and healing behavior of dental implants using immediate/early loading protocol using Resonance Frequency Analysis ISQ system in the posterior mandible.

MATERIALS AND METHODS

A clinical trial was conducted on fourteen adult patients of both sexes (9 males and 5 females) having missing mandibular molar teeth indicated for implant rehabilitation. The patients were selected from the Out Patient Clinic of the Oral & Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University.

The inclusion criteria of this study were; patients' age ranging from 25-40 years, adequate bone height above the inferior alveolar canal, minimum bone width of 6 mm and good oral hygiene. While the exclusion criteria were; parafunctional habits, heavy smokers, untreated periodontitis and medically compromised patients such as osteoporosis, liver cirrhosis and hyperparathyroidism.

The dentium superline system implants (Seoul, Korea) with different diameters (3.8, 4.3 and 4.8 mm) and lengths (8, 10 and 12 mm) were used in this study, and Osstell ISQ was used for measurement of implant stability.

Osstell ISQ (Osstell AB, Göteborg, Sweden) consists of Osstell portable ISQ instrument, probe, charger, USB cable and test peg.

The system includes the use of a SmartPeg™ attached to the dental implant by means of an integrated screw. The SmartPeg is excited by a magnetic pulse from the measurement probe on the handheld instrument. The resonance frequency, which is the measure of implant stability, is calculated from the response signal. Results are displayed on the instrument screen as the Implant Stability Quotient (ISQ), which is scaled from 1 to 100. The higher the value, the more stable the implant.

All patients underwent pre-operative clinical examination: Patients' data were collected; name, gender and age, medical and dental histories were taken and the oral mucosa of the edentulous area was examined by inspection and palpation. Also all patients underwent standardized periapical radiography to view any periapical pathology and a pre-operative panoramic radiograph examination to evaluate the height of the bone available above the inferior alveolar canal. (Fig 1)

All patients were instructed to rinse with chlorhexidine mouth wash (Listermix plus, SIGMA Pharmaceutical Industries, Egypt) immediately before operation for 2 minutes.

With the patient under local anesthesia (Septodont, articaine HCL and epinephrine 1:20.000) a full thickness mucoperiosteal envelope flap was raised, osteotomy was carried out in the alveolar bone guided by the neighboring teeth, the initial marking or preparation of the implant bed was done with a pilot drill (point drill) of 2.2 mm, the osteotomy was then widened using an intermediate drill and the final drill according to the diameter of the implant, the implant was then threaded into the bone using a Ratchet, the SmartPeg™ was attached to the implant fixture, the implant stability was measured by Osstell ISQ. In the immediate loading protocol, a titanium abutment was connected immediately and a provisional restoration was prefabricated and temporarily cemented. In the early loading protocol, a healing cap was placed and left for a month. The flaps were sutured using 3/0 black silk sutures. (Figs 2,3)

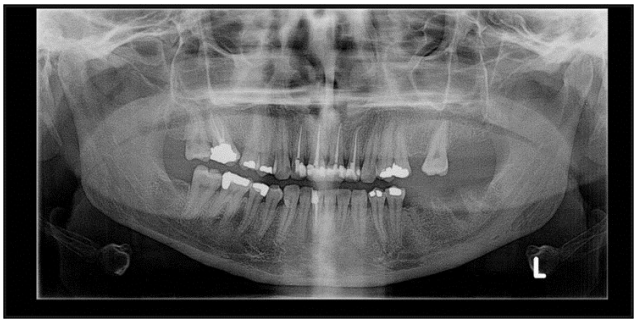

Figure 1: Preoperative panoramic radiograph showing missing mandibular lower left first molar in the early loading group.

All patients were advised to apply cold packs extra orally intermittently every 10 minutes for 2 hours on the first day, chlorohexidine mouth wash (Listermix plus) was started on the 2nd post-operative day for one week, the sutures were removed after one week post surgically. Antibiotic (Amoxicillin/claviulanic acid 1 gm tab) (Augmentin, Glaxosmithkline, Australia), two times daily for 5 days, non-steroidal anti inflammatory drugs (diclofenac sodium 50 mg tabs) (Cataflam, Novartis pharma, Basel, Switzerland), three times daily for 3 days were given.

All patients were evaluated clinically immediately post-operatively and on intervals of 1, 3 and 6 months, for presence of periimplantitis, probing depth, modified plaque index and modified sulcus bleeding index (25), then the implant stability measurement was examined at the day of surgery as the baseline and at 1, 3 and 6 months postoperatively using the Resonance Frequency Analysis via the Osstell ISQ system.

All the implants involved in this study were followed up radiographically at 1, 3 and 6 months intervals. (Fig 4)

Final prosthesis (porcelain fused to metal crown) was inserted after three months.

The statistical analysis was performed to compare the implant stability quotient (ISQ) in the immediately and the early loaded implants immediately post-operative and on intervals of 1, 3 and 6 months in the posterior mandible.

Data were represented as mean and standard deviation. Repeated measures analysis of variance (ANOVA) test was used to compare numeric variables within the studied group of patients.

Post Hoc test was done if ANOVA or Friedman tests were positive.

In all tests, result was considered statistically significant if the p- value was less than 0.05.

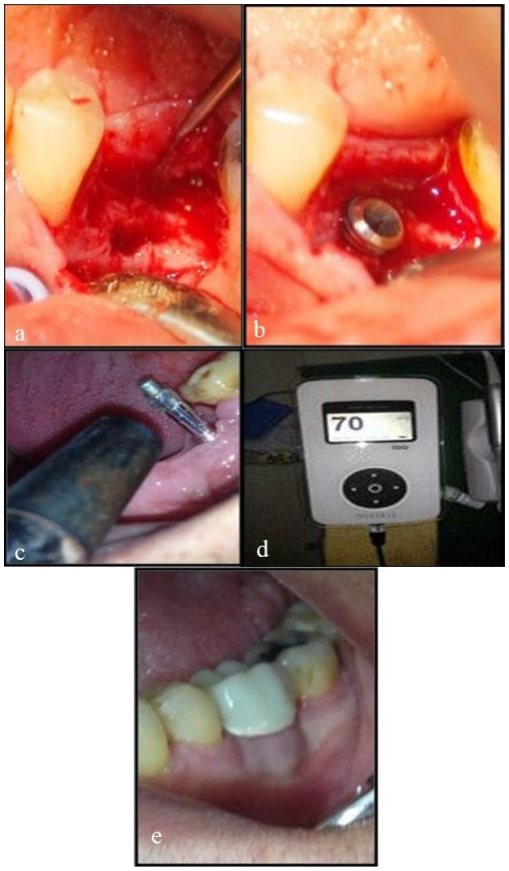

Figure 2: A photograph showing the implant placement surgical procedures and implant stability measurement in the immediate loading protocol. (a) mucoperiosteal envelope flap reflection. (b) implant inserted. (c) the instrument probe exciting the SmartPeg. (d) measurement displayed on the portable instrument screen. (e) provisional restoration immediately post-operatively cemented to the abutment.

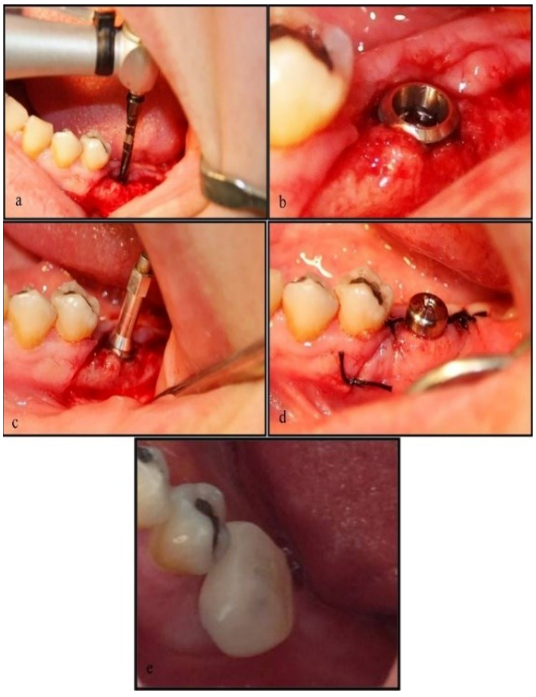

Figure 3: A photograph showing the implant placement surgical procedures and implant stability measurement in the early loading protocol. (a) intermediate drill. (b) implant inserted. (c) SmartPeg screwed to the implant. (d) healing abutment. (e) provisional restoration cemented to the abutment after one month.

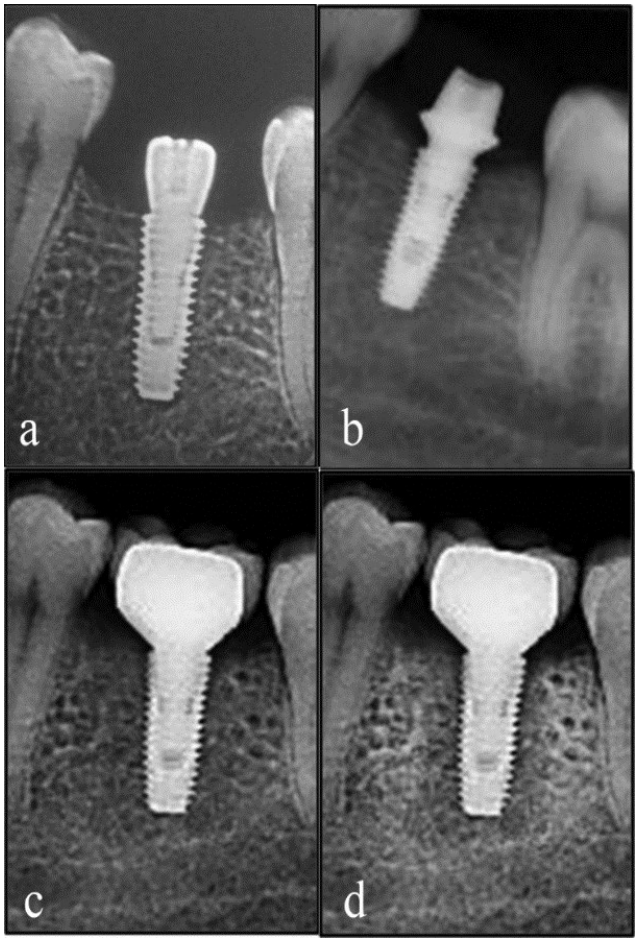

Figure 4: Periapical x-ray of the implant (early loading) throughout the follow up period. (a) immediately postoperatively. (b) 1st month postoperatively. (c) 3rd month postoperatively. (d) 6th month postoperatively.

RESULTS

Fourteen implants were placed in a total of fourteen patients (9 males and 5 females) having missing mandibular molar teeth. Their ages ranged between 27 and 40 years with mean age of 35 years (Table 1). They were selected from the Outpatient Clinic of the Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University.

All patients underwent surgical operations under local anesthesia using full thickness flap technique and implant placement, and no complications had been recorded during the operation.

Table 1: All cases of both groups regarding age and gender.

Group I			Group II		
Cases	Age	Gender	Cases	Age	Gender
1	37	Male	1	28	Male
2	33	Female	2	36	Male
3	35	Male	3	35	Male
4	32	Female	4	26	Female
5	29	Female	5	37	Female
6	27	Male	6	41	Male
7	31	Male	7	29	Male

All patients had been examined periodically during the follow-up period up to 6 months. Healing was uneventful in all cases with no post-operative complications. Other clinical parameters had been recorded such as: Modified plaque index, modified sulcus bleeding index and Implant Stability.

1) Plaque index; plaque index decreased in all patients on the 3rd and 6th month. The decrease on the 3rd and 6th month in all patients was statistically significant (Table 2).
2) Bleeding index; bleeding index decreased in all patients on the 3rd and 6th month. The decrease on the 3rd and 6th month in all patients was statistically significant (Table 2).
3) Implant Stability Evaluation; in the immediate loading group I, the mean implant stability quotient immediately post-operative was 69.0±10.71. There was a decrease after 1st month (66.57±6.24). There was an increase after 3rd and 6th months (71.29±2.14, 71.29±4.61 respectively).

Table 2: Statistical analysis of Modified sulcus bleeding index (mSBI) and Modified Plaque index throughout the study period.

Sulcus bleeding index	1 month	3 months	6 months
Group I			
Range	0.25 – 1.25	0.25 – 1.0	0.0 – 0.75
Mean ± SD	0.78 ± 0.36	0.63 ± 0.23	0.22 ± 0.28
Median	0.75	0.63	0.13
P		0.357	0.008*
Group II			
Range	0.25 – 1.25	0.25 – 1.0	0.0 – 75.0
Mean ± SD	0.75 ± 0.35	0.53 ± 0.28	0.25 ± 0.27
Median	0.75	0.50	0.25
P		0.279	0.010*
p_1	0.871	0.445	0.738
Plaque index	**1 months**	**3 months**	**6 months**
Group I			
Range	0.75-1.5	1.0-2.0	1.0-2.0
Mean ± SD	0.975±0.30	0.732±0.25	0.6±0.17
P		0.032*	0.008*
Group II			
Range	0.72-1.0	1.5-2.0	1.0-2.0
Mean ± SD	0.82±0.27	0.61±0.25	0.45±0.18
P		0.029*	0.006*
^{MW}P	0.36	0.41	0.16

p: p value for Wilcoxon signed ranks test for comparing between 1 month and other study periods
p_1: p value for Mann Whitney test for comparing between the two study groups

In the early loading group II, the mean implant stability quotient immediately post-operative was 61.86±14.22. There was a decrease after 1st month (59.86±11.42). There was an increase after 3rd and 6th months (75.86±3.18, 77.71±1.60 respectively).

In the immediate loading group, the mean implant stability quotient (ISQ) was higher than the early loading group immediately post-operative. The values were 69.0±10.71 and 61.86±14.22 respectively. The difference in mean implant stability quotient (ISQ) between both groups immediately post-operative was statistically insignificant. (p=0.309).

In both groups, the decrease in implant stability after one month was not statistically significant (p=0.197). The increase in implant stability quotient after 3 months between the studied groups was statistically significant (p=0.008). The increase in the early loading group was higher than the immediate group. The increase in implant stability quotient after 6 months between the studied groups was statistically significant (p=0.009). The increase in the early loading group was higher than the immediate group. (Table 3, Fig 5)

Table 3: Comparison between the two studied groups according to implant stability quotient (ISQ).

	ISQ			
	Day 0	**1 Month**	**3 Months**	**6 Months**
Immediate group (n = 7)				
Min. – Max.	55.0 – 82.0	60.0 – 76.0	70.0 – 76.0	65.0 – 77.0
Mean ± SD.	69.0 ± 10.71	66.57 ± 6.24	71.29 ± 2.14	71.29 ± 4.61
Median	70.0	66.0	71.0	72.0
p_1		0.679	0.565	0.653
Early group (n = 7)				
Min. – Max.	44.0 – 75.0	44.0 – 72.0	72.0 – 79.0	76.0 – 79.0
Mean ± SD.	61.86 ± 14.22	59.86 ± 11.42	75.86 ± 3.18	77.71 ± 1.60
Median	65.0	63.0	75.0	79.0
p_1		0.812	0.075	0.017*
t	1.062	1.365	3.153*	3.486*
p	0.309	0.197	0.008*	0.009*

p_1: p value for Post Hoc Test (LSD) for F test (ANOVA) with repeated measures for comparison between day 0 with each other period
t: Student t-test
*: Statistically significant at $p \leq 0.05$

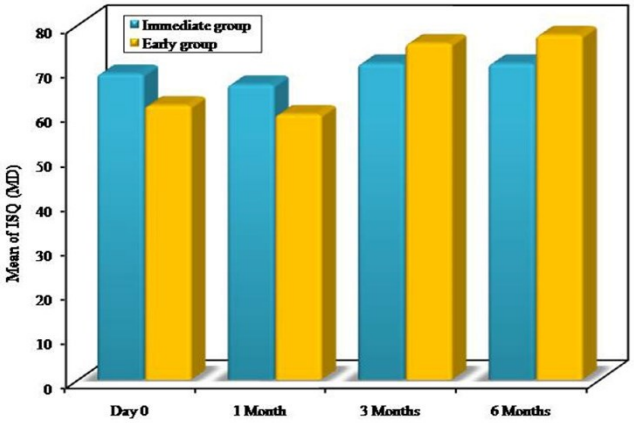

Figure 5: A column chart showing the change in mean implant stability between the two groups throughout the study period.

DISCUSSION

Studies of immediate loading in the literature (6-13) show data for long-term osseointegration comparable to the results of Brånemark and coworkers' classic 2-stage study (4); however, the stability of the implant over the initial short-term period after implantation has yet to be studied thoroughly.

Therefore, the present study was designed to evaluate the implant stability of immediately and early loaded dental implants in the posterior region of the mandible.

The present study was conducted on fourteen patients having missing mandibular molars. They were selected from the Outpatient Clinic of the Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University.

All patients in the present study were selected free from parafunctional habits such as bruxism and clenching, which increase the magnitude of the forces. In such patients, the duration of the forces are extensive and their direction is more horizontal than axial to the implants, which leads to mechanical complications and failure of implants (26).

In the present study, the implant stability was measured using the Resonance Frequency Analysis (RFA) via the Osstell ISQ system. Resonance frequency analysis was chosen as a non-invasive and reliable method to assess variation in implant stability over time. Resonance frequency analysis registrations

are directly related to the stiffness of the implant in the surrounding bone: during healing, an increase in implant stability quotient (ISQ) values presumably reflects new bone apposition at the implant-bone interface (19,27-31).

In the present clinical study, implant stability quotient (ISQ) increased in both the immediate and the early loading groups after 3rd month and 6th month. In the immediate loading, the mean implant stability was 71.29±2.14, 71.29±4.61, and in the early loading, the mean implant stability was 75.86±3.18, 77.71±1.60 respectively.

This agreed with a recent prospective clinical study evaluating immediate loading of implants in the partially edentulous mandible, ISQ was measured at implant placement and after 6 months of loading, with values of 72.2 and 72.5, respectively (24).

Based on the preliminary data of Glauser and colleagues (32), immediate loading should be possible where the ISQ is greater than 60 at implant placement.

The idea that ISQ values of 60 to 65 could be safe for immediate loading is based on the observation that most implants eventually achieve a secondary stability within this range in the period after the initial healing phase (32).

In a follow-up study on implants placed in extraction sockets and subjected to immediate/early loading, ***Vanden Boagerde*** and co-workers (33) demonstrated rescue of one implant based on resonance frequency analysis measurements. This implant showed a significant drop from 67 ISQ to 53 ISQ during the first six weeks. The implant was unloaded and recovered to an ISQ value of 72 after 6 months.

Huwiler et al. (34), in a series of 17 implants placed in patients, observed a normal ISQ range between 55 and 74 at the time of implant insertion. They also observed an increase in ISQ values during the week following implant insertion, followed by a decrease during weeks 2 to 4, and a posterior increase to ISQ values obtained during the insertion phase, or even higher.

This agreed with the present study, in both groups, there was a decrease in ISQ values after 4th week, then a gradual increase to the 3rd month, and 6th month reaching ISQ above 70. In the early study group, the increase in ISQ values was higher throughout the follow up period.

All implants used in this study were sandblasted with large grit and acid etched surface (SLA), and were subjected to immediate/early loading protocol in the posterior mandible.

In a study for surface treatment effect on the stability ***Kim et al.*** (35), reported that surface treatment may have significant effects on biological stability 3 weeks after implant placement.

In a prospective study comparing early and immediate loading, ***Achilli et al*** (36) evaluated 32 oxidized titanium tapered implants that were inserted in mandibular molar and premolar sites and loaded after 6 weeks with fixed dental prosthesis. A 100% success rate was reported after 1 year .

In a recently published randomized clinical trial, ***Ganeles*** and coauthors (37) compared early and immediate loading of implants placed in posterior sites of both jaws. A total of 134 implants with a chemically modified SLA surface were placed in the posterior mandible and loaded after an interval of 28 to 34 days with either single crowns or fixed dental prosthesis. Four early failures and one failure after loading were reported, leading to a 96%implant survival rate .

In a case series study, ***Buchs*** and coworkers (38) reported a 92.7% success rate one year after immediate loading of titanium oxide-blasted implants in the posterior mandible either with single crowns or fixed dental prosthesis.

Abboud and coworkers (39) investigated 20 immediately loaded sandblasted implants for single-tooth replacement in premolar or first molar areas. Of these, 11 were mandibular implants that showed a 100% survival rate at the 12-month follow-up.

Therefore, the present clinical study demonstrated a good prognosis for the immediate/early loading of dental implants in the posterior mandible and the implant stability values reached acceptable values using resonance frequency analysis by the Osstell ISQ.

CONCLUSIONS

There was an increase in implant stability quotient (ISQ) values after 3rd and 6th month using an immediate/early loading protocol in the posterior mandible. The survival rate was 100%. The increase in implant stability in the early loading was higher. Resonance frequency analysis is a reliable non-invasive method to predict bone healing around implants throughout the follow up period.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

INFORMED CONSENT

Appropriate institutional ethical clearance and written informed consent were obtained.

REFERENCES

1. Brånemark PI. Introduction to osseointegration. In: Brånemark PI, Zarb GA, Albrektsson T, (eds). Tissue-integrated prostheses: Osseointegration in clinical dentistry. 1st ed. 1985, Chicago: Quintessence Publ. Co. 11-71.
2. Berglundh T, Abrahamsson I, Lang NP, Lindhe J. De novo alveolar bone formation adjacent to endosseous implants. Clin Oral Implants Res 2003; 14: 251-62.
3. Misch CE, Wang HL, Misch CM, Sharawy M, Lemons J, Judy KW. Rationale for the application of immediate load in implant dentistry: Part I. I Implant Dent 2004; 13: 207-15.
4. Brånemark P-I, Hansson BO, Adell R, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. Scand J Plast Reconstr 1977; 16: 1-132.
5. Adell R, Lekholm U, Rockler B, Brånemark P-I. A 15-year study of osseointegrated implants in the treatment at the edentulous jaw. Int J Oral Surg 1981; 10: 387-416.
6. Brånemark P-I, Engstrand P, Ohrnell L-O, Gröndahl K, Nilsson P, Hagberg K, et al. Brånemark Novum: A new treatment concept for rehabilitation of the edentulous mandible. Preliminary results from a prospective clinical follow-up study. Clin Implant Dent Relat Res 1999; 1: 2-16.
7. Schnitman PA, Wöhrle PS, Rubenstein JE, DaSilva JD, Wang NH. Ten-year results for Brånemark implants immediately loaded with fixed prostheses at implant placement. Int J Oral Maxillofac Implants 1997; 12: 495-503.

8. Tarnow DP, Emtiaz S, Classi A. Immediate loading of threaded implants at stage 1 surgery in edentulous arches: ten consecutive case reports with 1- to 5-year data. Int J Oral Maxillofac Implants 1997; 12: 319-24.
9. Chiapasco M, Gatti C, Rossi E, Haefliger W, Markwalder TH. Implant-retained mandibular overdentures with immediate loading. A retrospective multicenter study on 226 consecutive cases. Clin Oral Implants Res 1997; 8: 48-57.
10. Ericsson I, Randow K, Nilner K, Peterson A. Early functional loading of Brånemark dental implants: 5-year clinical follow-up study. Clin Implant Dent Relat Res 2000; 2: 70-7.
11. Gatti C, Haefliger W, CHiapasco M. Implant-retain mandibular overdentures with immediate loading: A prospective study of ITI implants. Int J Oral Maxillofac Implants 2000; 15: 383-388.
12. Wolfinger GJ, Balshi TJ, Rangert B. Immediate functional loading of Brånemark system implants in edentulous mandibles: clinical report of the results of developmental and simplified protocols. Int J Oral Maxillofac Implants 2003; 18: 250-257.
13. Schnitman P, Wohrle P, Rubenstein J. Immediate fixed prostheses supported by two-stage threaded implants. Methodology and results. J Oral Implantol 1990; 16: 96-105.
14. Meredith N, Alleyne D, Cawley P. Quantitative determination of the stability of the implant-tissue interface using resonance frequency analysis. Clin Oral Implants Res 1996; 7: 261-7.
15. Wennerberg A, Albrektsson T, Andersson B, Krol JJ. A histomorphometric and removal torque study of screw-shaped titanium implants with three different surface topographies. Clin Oral Implants Res 1995; 6: 24-30.
16. Carlsson L, Albrektsson T, Berman C. Bone response to plasma-cleaned titanium implants. Int J Oral Maxillofac Implants 1989; 4: 199-204.
17. Olive J, Aparicio C. The periotest method as a measure of osseointegrated oral implant stability. Int J Oral Maxillofac Implants 1990; 5: 390-400.
18. Veltri M, Balleri P, Ferrari M. Influence of transducer orientation on Osstell stability measurements of osseointegrated implants. Clin Implant Dent Relat Res 2007; 9: 60-4.
19. Meredith N, Book K, Friberg B, Jemt T, Sennerby L. Resonance frequency measurements of implants stability in vivo. A cross-sectional and longitudinal study of resonance frequency measurements on implants in the edentulous and partially dentate maxilla. Clin Oral Implants Res 1997; 8: 226-33.
20. Zarb GA, Alberktsson T. Criteria for determining clinical success with osseointegrated dental implants. Cah Prothese 1990; 71: 19-26.
21. Atsumi M, Park SH, Wang HL. Methods used to assess implant stability: current status. Int J Oral Maxillofac Impalnts 2007; 22: 743-54.
22. Jaramillo R, Santos R, Lazaro P, Romero M, Rios-Santos JV, Bullon P, et al. Comparative analysis of 2 resonance frequency measurement devices: Osstell Mentor and Osstell ISQ. J Implant Dent 2014; 23: 351-6.
23. Östman PO, Hellman M, Sennerby L. Direct implant loading in the edentulous maxilla using a bone density – adapted surgical protocol and primary implant stability criteria for inclusion. Clin Implant Dent Relat Res 2005; 7: 560-9.
24. Östman PO, Hellman M, Sennerby L. Occlusal loading of implants in the partially edentate mandible: A prospective 1-year radiographic and 4-year clinical study. Int J Oral Maxillofac Implants 2008; 23: 315-22.
25. Mombelli A, van Oosten MAC, Schürch E Jr, Land NP. The microbiota associated with successful or failing osseointegrated titanium implants. Oral Microbiol Immunol 1987; 2: 145-51.
26. Manfredini D, Poggio CE, Lobbezoo F. Is Bruxism a risk factor for dental implants? A systematic review of the literature. Clin Implant Dent Relat Res 2014; 16: 460-9.
27. Cochran DL, Schenk RK, Lussi A, Higginbottom FL, Buser D. Bone response to unloaded and loaded titanium implants with a sandblasted and acid etched surface: A histometric study in the canine mandible. J Biomed Mater Res 1998; 40: 1-11.
28. Brunski JB. Biomechanical factors affecting the bone-dental implant interface. Clin Mater 1992; 10: 153-201.
29. Davies JE. Mechanisms of endosseous integration. Int J Prosthodont 1998; 11: 391-401.
30. Sim CP, Lang NP. Factors influencing resonance frequency analysis assessed by osstellmentor during implant tissue integration: I. Instrument positioning, bone structure, implant length. Clin Oral Implants Res 2010; 21: 598-604.
31. Kessler-Liechti G, Zix J, Mericske-Stern R. Stability measurements of 1-stage implants in the edentulous mandible by means of resonance frequency analysis. Int J Oral Maxillofac Implants 2008; 23: 353-8.
32. Glauser R, Sennerby L, Meredith N, Rée A, Lundgren A, Gottlow J, et al. Resonance frequency analysis of implants subjected to immediate or early functional occlusal loading-successful vs. failing implants. Clin Oral Implants Res 2004; 15: 428-34.
33. Vanden Bogaerde L, Rangert B, Wendelhag I. Immediate/early function of Brånmark system Ti Unite implants in fresh extraction Sockets in maxillae and posterior mandibles. An 18-month prospective clinical study. Clin Implant Dent Relat Res 2005; 7(Suppl 1): 121-30.
34. Huwiler MA, Pjetursson BE, Bosshardt DD, Salv I GE, Lang NP. Resonance frequency analysis in relation to jawbone characteristics and during early healing of implant installation. Clin Oral Implants Res 2007; 18: 275-80.
35. Kim SJ, Kim MR, Rim JS, Chung SM, Shin SW. Comparison of implant stability after different implant surface treatments in dog bone. J Appl Oral Sci 2010; 18: 415-20.
36. Achilli A, Tura F, Euwe E. Immediate/early function with tapered implants supporting maxillary and mandibular posterior fixed partial dentures: Preliminary results of a prospective multicenter study. J Prosthet Dent 2007; 97(Suppl 6): S52-S8.
37. Ganeles J, Zöllner A, Jackowski J, Ten Bruggenkate C, Beagle J, Guerva F. Immediate and early loading of straumann implants with a chemically modified surface (SLActive) in the posterior mandible and maxilla: 1-year results from a prospective multicenter study. Clin Oral Implants Res 2008; 19: 1119-28.

38. Buchs AU, Levine L, Moy P. Preliminary report of immediately loaded altiva natural tooth replacement dental implants. Clin Implant Dent Relat Res 2001; 3: 97-106.
39. Abboud M, Koeck B, Stark H, Wahl G, Pailbn R. Immediate loading of single-tooth implants in the posterior region. Int J Oral Maxillofac Implants 2005; 20: 61-8.