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A literature review on progressive loading

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ABSTRACT

Aim The planning of implant-supported dentures can become complex when the patient has low or poor quality of bone. Some studies suggest that excessive functional load or traumatic occlusion over dental implants placed in bone of poor quality and density may cause marginal bone loss and increase implant failure rate. In 1980, Misch proposed the progressive loading of a dental implant. A protocol that may produce a lower crestal bone loss compared to the conventional loading protocol, as well it may increase bone density in poor quality areas. The aim of this review of the literature was to update and summarize the progressive loading protocol and to describe its benefits and its possible effect on dental implant success.

Methods The following combinations of controlled terms (MeSH) and keywords were used: ("progressive loading"[All Fields] OR "progressive bone loading"[All Fields] OR "progressive bone load"[All Fields] OR "progressive load"[All Fields]) AND ("dental implants"[MeSH Terms] OR "dental implant")

Conclusion Within the limitations of this study, all authors concluded that PL produces less crestal bone loss and trends to high bone density around dental implants. Authors also support the idea that PL may stimulate bone growth and maturation and offer benefits in bone quality and density and suggest the use of gradual loading especially in bones with low density.

KEYWORD Bone density, Dental implants, Implant loading, Progressive loading osseodensification.

INTRODUCTION

Implant dentistry has become a predictable and widely accepted option for patients with total or partial edentulism (1,2). This treatment is based on the osseointegration´s concept, which consists of the direct and close union between dental implant and bone surface without the interposition of any tissue (3,4).

An important factor to evaluate the success in implant therapy is the conservation of peri-implant bone (5) especially the bone crest, a critical area that can present physiological bone loss during the adaptation to occlusal forces (6) or due to overloading (7). The density of available bone is a determining factor when planning the surgical approach, healing time and time loading (8,9). Up to date, different loading protocols have been established and investigated (10,11) because several authors have affirmed that when the implant is loaded and enters into function the risk of failure increases (12,13).

Literature reports a higher failure rate in poor bone quality and density (14,15) especially in bone types III and IV(16,17) and when an implant is prematurely loaded into immature bone (7). For these cases, the progressive loading (PL) protocol is recommended (8). This concept supports the empirical idea that gradual loading causes bone maturation, improves density and bone quality, decreases crestal bone loss and early implant failure (18). Several studies have reported success rates of more than 90% for immediate and conventional loading protocols (19,20), but there are gaps in the literature if the progressive loading protocol produces changes in bone quality and density. There are only few studies that have evaluated it in the long term.

The aim of this review of the literature was to update and summarize the PL protocol and to describe its benefits and its possible effect on dental implant success.

METHODS

A literature search on the PubMed, MEDLINE and Cochrane Database was made to update the concept of progressive bone load on dental implants. The search included articles up to December 2018 and written in English. All levels of evidence (randomized controlled trials, prospective and retrospective studies, case series and animal studies) were considered for possible inclusion.

The following combinations of controlled terms (MeSH) and keywords were used: ("progressive loading"[All Fields] OR "progressive bone loading"[All Fields] OR "progressive bone load"[All Fields] OR "progressive load"[All Fields]) AND ("dental implants"[MeSH Terms] OR "dental implant")

The search identified 99 results and after applying language filters and read title and abstracts only 21 relevant articles were included in this review Process selection of articles to be included in this review is shown in figure 1.

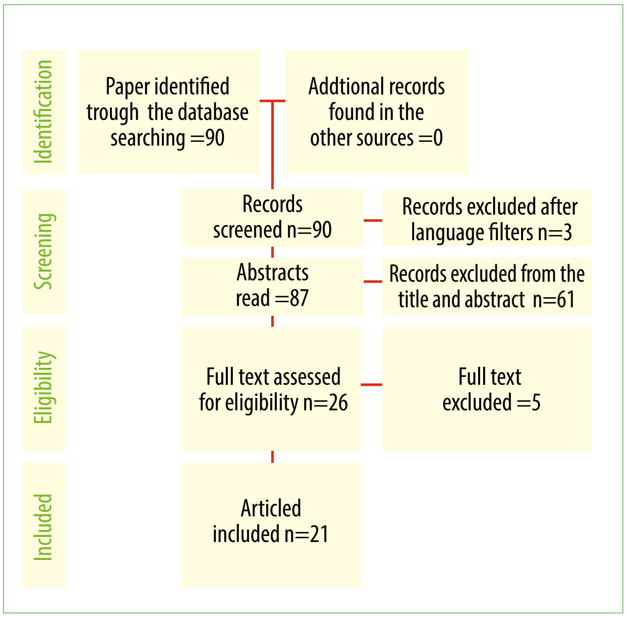

FIG. 3 Process selection

RESULTS

Concept of progressive loading

It was believed that osseointegration could only be achieved if no loads were applied to the implant for periods of not less than 3-4 months in the mandible and 5 to 6 months in the maxilla (3,21). Authors concluded that excessive functional load or traumatic occlusion might cause overstress leading to marginal bone loss around dental implants.(12,13). Currently information indicates that dental implants can be loaded immediately after placement when there are adequate height and bone density (22). But in bone types III or IV, a higher failure rate has been reported (16,17).

1993 reference

In 1983 Misch (23) introduced the concept of PL in 1980 and indicated that bone could mature when tension during the prosthetic phase increases gradually without overloading the implant. Bone is slightly overloaded and reacts by increasing its formation, growing denser and improving its quality.

This protocol uses transitional prostheses made of acrylic resin that minimally disturb the integration of the implant-bone interface during the healing phase (24).

Esposito et al. (25) defined PL as the load of the implants obtained by the gradual increase of the occlusal table height through increments from infraocclusion to complete occlusion.

In the study of Appleton et al. (26) infraocclusion was defined while the subject was applying his maximum biting force and a piece of 0.015 mm thick shim stock passed freely through the occlusal contact.

Observational studies

The literature shows that some authors use PL as a protocol in their studies (Table 1).

Payne et al. (27) conducted a study to clinically evaluate implant success in early and PL of 20 unsplinted conical Branemark implants of 10 edentulous patients with overdentures in the lower jaws. For immediate PL following surgery, tissue conditioners in the patient's dentures were used. Radiographic marginal bone levels were measured and individual stability was evaluated using Periotest. On the conical implants, marginal bone was between limits of success, 0.22 mm (SD = 0.48 mm) mesially and 0.30 mm (SD = 0.39 mm) distally. Periotest values did not show statistically significant levels.

Anitua et al. (28) described a novel drilling technique for the treatment of severely atrophied mandible with extra short implants supported by prostheses with PL. They used 2- stage drilling perforations for the visual control of the depth avoiding the injury of the mandibular nerve and acrylic provisionals supported by screws. The study found an implant survival rate of 98.2% and a mean marginal bone loss proximal to implants of 1mm without any prosthetic complications.

Arora et al. (29) recommended its use to prevent microfractures during bone remodeling. In this study, they compare crestal bone loss and pocket depth around 80 platform-switched implants placed in the maxillary anterior region (MAR) and in the mandibular posterior region (MPR). They found a significantly higher amount of bone loss in the MAR group. Pocket depths were significantly greater in palatal regions of the mandible (p = 0.01) and in distal regions in the maxilla (p = 0.002).

Comparative studies

Animal studies: only one animal study by Podaropoulos

AUTHORS (YEAR)	Payne et al. (2001)27	Falisi (2013)32	Anitua et al (2013)28	Arora et al (2015)29
STUDY TYPE	Observational longitudinal study	Longitudinal retrospective study	Retrospective study	Observational longitudinal study
TREATMENT GROUP(S)	Cohort of 10 patients with conical implants placed in the anterior mandible With mandatory primary stability with bicortical anchorage and ball abutment connection	Cohort of 11patients	Loading period ≤ 12 months Loading period >12 months	Group – ANT: single missing tooth in maxillary anterior region Group – post: single missing tooth in mandibular Posterior region)
PATIENTS (N) / AGE	10 55-80 years old	11	72 58±9 years	80 25- 45 years
NO. OF IMPLANTS	20	30	114 extra short – implants	80 Group – ANT: 40 implants Group – POST: 40 implants
TYPE OF RESTO-RATION	Conventional mandibular dentures temporarily relined with tissue conditioner and worn with moderation for the first 2 weeks to allow progressive loading. Early loading of the implants followed 2 weeks.	Provisional prosthesis	Implant supported prostheses in the posterior mandible with progressive loading	The first and second Transitional prosthesis in acrylic, and finally a porcelain-fused to metal crown as definitive prosthesis for both groups
ASSESSMENT TECHNIQUE	Panoramic and lateral cephalometric radiographs Periotest	Implant Stability quotient(ISQ) by resonance frequency X ray Cone beam CT scans	Cone beam CT scans	Digital x- ray Pocket depths were recorded using plastic Probes
IMPLANT SYSTEM	Conical Branemark Implants	11.5 x 4mm Tekka implants (sand-blasted And double acid etch)	Not specified	4×11.5 mm (GS-II, osstem, Seoul, south Korea)
FOLLOW UP	2, 6, 12, And 52 weeks.	0,6,12 months Isqt1= 0 months ISQT2= 6 months ISQT3= 12 months	Of at least 12 months after implant insertion. 6, 12 months - anually	6-month
MEASURED OUTCOMES/ RESULTS	Marginal bone 0.22 mm (SD = 0.48 mm) mesially on the conical implants 0.30 mm (SD = 0.39 mm) distally on the conical implants	Implants lost 2 Implant stability ISQ T0 vs ISQ T1, z = 3.408 ISQ T0 vs ISQ T2, z = 7.016 ISQ T1 vs ISQ T2, z = 3.608 Critical z = 2.394	Implant survival rate 98.2% Marginal bone loss proximal to implants 1mm (mean)	Bone loss Group – ant: 40 implants1.2 ± 0.3 Mm Group – POST: 40 implants0.7 ± 0.02 mm Pocket depth increase Group – ant: palatal (p = 0.01) Group – POST: distal (p = 0.002).

TABLE 1 **Observational studies that included progressive loading as a loading protocol**

et al. (30) was found. They evaluated bone reaction around dental implants to static PL. The study used controlled orthodontic forces on osseointegrated implants placed in 3 beagle dogs.
The percentage of bone-to implant contact in the PL group increased significantly (P = 0.018). No differences were found in crestal bone resorption between groups (P = 0.813) or in bone density 1mm (P = 0.734) or 2 mm (P = 0.961) distant to the threads.
Table 2 summarize animal studie.s
Comparative clinical studies: although this theory was based on empirical information, the efficiency of PL is supported by a few clinical prospective studies. The summary of prospective clinical studies is shown in table 3.
In 2005, Appleton et al. (26) conducted a study to compare the effectiveness of PL versus direct load to preserve crestal bone loss and improving peri-implant bone density around dental implants supporting single tooth restorations after a healing period of 5 months. They demonstrated that progressively loaded group reported less crestal bone loss (0.2 ±0.27 mm) compared to conventional loading (0.59±0.27 mm). These differences were statistically significant (P ≤ 0.05).
Ghoveizi et al. (18) performed a similar study but with a shorter healing period (2 months) and reported an increase in bone density when a PL protocol

AUTHORS (YEAR)	Podaropoulos et al (2015)30
STUDY TYPE	Experimental study in animals
ANIMAL MODEL / n	Beagle dogs/ 3
NO. OF IMPLANTS/ IMPLANT SYSTEM	24 OsseotitE surface and machined neck implants (Biomet 3i, Palm Beach Gardens, FL, USA).)
TREATMENT GROUP(S)	Experimental group: 12 progressive Loading (PL) control group: 12 Unloaded (UL)
TYPE OF RESTORATION	Abutments were adapted and connected by pairs with Ni-Ti orthodontic springs PL:A gradual static force of 100, 200 and 300 g was applied for a 3-week period each. UL: left to heal undisturbed
ASSESSMENT TECHNIQUE	Clinical, histologic and histo-morphometric
TORQUE INSERTION	Not specified
FOLLOW UP	9-week loading period
MEASURED OUTCOMES/ RESULTS	Bone-to-implant contactPL group exhibited significantly higher percentage (P = 0.018). Bone density 1mm distant to the threads P = 0.734 Bone density 2mm distant to the threads P = 0.961 Crestal bone resorption (P = 0.813).

TABLE 2 Animal studies.

was used. They also found less crestal bone loss around progressively loaded implants (0.11mm) when compared to the conventionally loaded group (0.36mm) after 12 months (P<0.05). On the other hand, Turner et al. (31) used the Periotest to study implant mobility in the progressively loaded and conventionally loaded group and recommended the use of PL when there is poor bone quality.
Falisi et al. (32) evaluated the stability of implants applied with fit lock method in upper maxillae with bone availability less than 4 mm in 3 follow-up periods (0, 6 and 12 months) finding that implant stability increased progressively over time after placement. A significant difference was found between the three follow-up periods. ISQ T2 was higher than ISQ T1 and ISQ T1 was higher than ISQ T0 (p=0.000). They concluded that implants placed with this technique in areas with poor bone availability showed a similar stability as reported with other techniques.
Khorshid et al. (33) evaluated changes in the peri-implant supporting structures when comparing two different immediate loading protocols (functional and progressive). They found a more favorable bone reaction with a statistically significant difference ($P \leq 0.009$) in the buccolingual and mesiodistal surfaces of immediate implants. Juboori et al. (34) measured implant stability during the healing period and throughout the follow-up. The study showed significant differences between delayed loading and immediate progressive loading implants (IPL). IPL enhances soft and hard tissue maturation and implant stability.

Systematic reviews

In 2013 Esposito et al. (25) conducted a systematic review to estimate success rates between different loading time protocols but when evaluated the effects of direct loading versus PL immediate, early and conventional did not identify any trials to make a conclusion.

DISCUSSION

Benefits of the progressive loading

Crestal bone loss on conventional loading has been reported between 0.9 to 1.6 mm after the first year of implant placement and an annual average loss of 0.05 to 0.13mm. Crestal bone loss around progressively loaded implants showed less bone loss than in conventionally placed implants (18,26,33). Observational studies have reported less marginal bone loss when used PL as a protocol (27,28) reporting survival rates of 98.2% and some authors recommend its use when the cortical bone is very thin or even lacking (21,35).
Different studies even have described that PL considerably improves the stability of the implant (31,32,34).
An important factor in deciding to use PL is the type of bone (bone quality) of the patient. Goodacre et al. (36) evaluated 7 studies to compare 3192 dental implants placed into different types of bone. The results showed implant loss in 16% of implants placed into type IV bone and only 4% in types I to III. Based on this review, Sheridan (37) suggested a solution based on the use of PL of the implant in patients with poor bone quality (type IV).

CONCLUSIONS

Within the limitations of this study, all authors concluded that PL produces less crestal bone loss and trends to high bone density around dental implants.
Authors also support the idea that PL may stimulate bone growth and maturation and offer benefits in bone quality and density and suggest the use of gradual loading especially in bones with low density.

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AUTHORS (YEAR)	Appleton et al (2005)26	Khorshid et al (2011)33	Ghoveizi et al (2013) 18	Turner (2014)31	Juboori et al (2018)34
STUDY TYPE	Prospective and controlled clinical trial	Prospective and controlled clinical trial	Prospective randomized controlled trial	Prospective and controlled clinical study	Pilot study randomized controlled clinical trial
PATIENTS (n) / AGE	20	5 40.3 years average	10 34-62 years old	15	6
NO. OF IMPLANTS / TREATMENT GROUP(S)	23 Experimental group Progressive loading Control group: Conventional Loading	30 Immediate Functional loading group (IFG)=15 Immediate Progressive loading group (IPG)= 15	20 Experimental group Progressive loading (EG)= 10 Control group: Conventional Loading (CG)= 10	25 Progressive loading group (PL)=14 Conventional Loading group (CL)= 11	12 Delayed loading (DL)= 6 Immediate progressive loading group (IPL)= 6
TYPE OF RESTORATION	EG: screw retained Provisional restorations CG: metal ceramic Crown	IFG: acrylic resin in full occlusal contact IPG: acrylic resin in	EG: cemented temporary heat cured acrylic resin crowns CG: metal ceramic Crown	PL: composite resin provisional Restorations CL: Porcelain fused to metal (PFM) crowns.	DL: Temporary crowns after 4 months IPL: temporary plastic abutment, and light-cured composite crowns
ASSESSMENT TECHNIQUE	X- ray	Computer X- ray infraocclusion	Computer X- ray	Periotest	X-ray
TORQUE INSERTION	Not specified	30 N/cm	At least 30 N/cm	Not specified	DL: more than 30 N/cm IPL: less than 30 N/cm
IMPLANT SYSTEM	HA - coated dental implant System (omnilocs or threadlocs, calcitekInc., Carlsbad, CA, USA)	Screw Indirect one-piece implants (ImplantDirect LLC Spectra-System Dental Implants, Calabasas Hills, CA)	Micro Thread-OsseoSpeed; Astra Tech, Mölndal, Sweden	ANKYLOS implants (Dentsply Implants, Hanau, Germany)	SLA (Superline, Dentium).
FOLLOW UP	2, 4, 6, 9, and 12 Months	4, 9, and 24 months	2, 4, 6, 8, and 12 Months	0 and 45 days after cementation	1, 2, 3 and 6 months.
MEASURED OUTCOMES/ RESULTS	Crestal bone height loss Eg: 0.2 ±0.27mm Cg: 0.59 ±0.27 Statistically significant (P≤ 0.05).Bone density EG: higher bone density gain in the crestal area CG: trend for higher bone density gain at the apex of The implants.	Crestal bone height loss IFG: A decrease in the percentage change of the crestal bone height in buccolingual and mesiodistal surfaces (P≤ 0.011) Bone density IFG: trend for decrease bone density in buccolingual and mesiodistal surfaces. (P ≤0.009)	Crestal bone height loss EG: 0.11 (0.19) mm CG: 0.36 (0.36) mm Statistically significant (P≤ 0.05).Bone densityEG: trend for higher bone density but not statistically significant (P > 0.05).	Periotest values in CL group At day 0 and 45 Good bone quality: -2.5/ -2.74 p = 0.0723 > 0.025 Poor bone quality: -2.08/-1.38 p= 0.0211 < 0.025 decrease in rigidity was found to be significantly lower in poor bone quality Periotest values in PL group At day 0 and 45 Good bone quality: -4.8/-5.6 p= 0.0143 < 0.025 Poor bone quality: -3.5 /-5.01p= 0.000264 < 0.025 Significantly increased implant rigidity in both groups with progressive loading. (P=0.001)	Mean ISQ value at surgery, 1, 2,3 and 6 months DL: 57,-, - 69, 76 IPL: 63, 73,75, 76, 79 significant differences between DL and IPL groups

TABLE 3 Comparative clinical studies

Conflict of interests

The authors declare no potential conflict of interests.

REFERENCES

1. Lambrecht JT, Filippi A, Künzel AR, Schiel HJ. Long-term evaluation of submerged and nonsubmerged ITI solid-screw titanium implants: a 10-year life table analysis of 468 implants. Int J Oral Maxillofac Implants. 2003 Nov-Dec;18(6):826-34.
2. Romeo E, Chiapasco M, Ghisolfi M, Vogel G. Long-term clinical effectiveness of oral implants in the treatment of partial edentulism. Seven-year life table analysis of a prospective study with ITI dental implants system used for single-tooth restorations. Clin Oral Implants Res. 2002 Apr;13(2):133-43.
3. Albrektsson T., Brånemark P.I., Hansson H.A., Lindström J. Osseointegrated titanium implants. Requirements for ensuring a long-lasting, direct bone-to-implant anchorage in man. Acta Orthop Scand. 1981;52:155-70
4. Brånemark PI, 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 Surg Suppl. 1977;16:1–132.
5. Astrand P, Engquist B, Dahlgren S, et al. Astra Tech and Brånemark system implants: a 5-year prospective study of marginal bone reactions. Clin Oral Implants Res. 2004 Aug;15(4):413–20.
6. Piao CM, Lee JE, Koak JY, et al. Marginal bone loss around three different implant systems: radiographic evaluation after 1 year. J Oral Rehabil. 2009 Oct;36(10):748–54
7. Roberts WE, Garetto LP, DeCastro RA. Remodeling of devitalized bone threatens periosteal margin integrity of endosseous titanium implants with threaded or smooth surfaces: indications for provisional loading and axially directed occlusion. J Indiana Dent Assoc. 1989 Jul-Aug;68(4):19-24.
8. Kribbs PJ, Smith DE, Chesnut CH., 3rd Oral findings in osteoporosis. Part II: Relationship between residual ridge and alveolar bone resorption and generalized skeletal osteopenia. J Prosthet Dent. 1983;50(5):719–24.
9. Vootla NR, Barla SC, Kumar V, et al. An Evaluation of the Stress Distribution in Screw Retained Implants of Different Crown Implant Ratios in Different Bone Densities Under Various Loads-A FEM Study. J Clin Diagn Res. 2016 Jun;10(6):ZC96-ZC101.
10. Esposito M, Grusovin MG, Maghaireh H, Worthington HV. Interventions for replacing missing teeth: different times for loading dental implants. Cochrane Database Syst Rev. 2013 Mar 28;(3):CD003878.
11. Morton D, Gallucci G, Lin WS, et al. Group 2 ITI Consensus Report: Prosthodontics and implant dentistry. Clin Oral Implants Res. 2018 Oct;29 Suppl 16:215-223..
12. Adell R, Lekholm U, Rockler B, Brånemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg.1981 Dec;10(6):387-416.
13. 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(2):70-7.
14. Olmedo-Gaya MV, Manzano-Moreno FJ, Cañaveral-Cavero E, et al. Risk factors associated with early implant failure: A 5-yearretrospective clinical study. J Prosthet Dent. 2016; 115: 150–155.
15. Misch CE. Progressive loading of bone with implant prostheses. J Dent Symp. 1993 Aug;1:50-3
16. Mohajerani H, Roozbayani R, Taherian S, Tabrizi R. The Risk Factors in Early Failure of Dental Implants: a Retrospective Study. J Dent (Shiraz). 2017 Dec;18(4):298-303.
17. Muelas-Jiménez MI, Olmedo-Gaya MV, Manzano-Moreno FJ, et al. Long -Term Survival of Dental Implants with Different Prosthetic Loading Times in Healthy Patients: A 5-Year Retrospective Clinical Study. J Prosthodont. 2017 Feb;26(2):99-106.
18. Ghoveizi R, Alikhasi M, Siadat MR, et al. A radiographic comparison of progressive and conventional loading on crestal bone loss and density in single dental implants: a randomized controlled trial study. J Dent (Tehran). 2013 Mar;10(2):155-63
19. Susarla SM, Chuang SK, Dodson TB. Delayed versus immediate loading of implants: survival analysis and risk factors for dental implant failure. J Oral Maxillofac Surg. 2008 Feb;66(2):251-5
20. Chrcanovic BR, Albrektsson T, Wennerberg A. Immediately loaded non-submerged versus delayed loaded submerged dental implants: a meta-analysis. Int J Oral Maxillofac Surg. 2015;44:493-506
21. Albrektsson T, Buser D, Sennerby L. On crestal/marginal bone loss around dental implants. Int J Periodontics Restorative Dent. 2013 Jan-Feb;33(1):9-11.
22. Gallucci GO, Hamilton A, Zhou W, et al. Implant placement and loading protocols in partially edentulous patients: A systematic review. Clin Oral Implants Res. 2018 Oct;29 Suppl 16:106-134.
23. Misch CE. Progressive loading of bone with implant prostheses. J Dent Symp. 1993 Aug;1:50-3
24. Perel ML. Progressive prosthetic transference for root form implants. Implant Dent. 1994;3:42–46
25. Esposito M, Grusovin MG, Achille H, Coulthard P, Worthington HV. Interventions for replacing missing teeth: different times for loading dental implants. Cochrane Database Syst Rev. 2009 Jan 21;(1):CD003878.
26. Appleton RS, Nummikoski PV, Pigno MA, et al. A radiographic assessment of progressive loading on bone around single osseointegrated implants in the poterior maxilla. Clin Oral Implants Res. 2005 Apr;16(2):161-7.
27. Payne AG, Tawse-Smith A, Kumara R, Thomson WM. One-year prospective evaluation of the early loading of unsplinted conical Brånemark fixtures with mandibular overdentures immediately following surgery. Clin Implant Dent Relat Res. 2001;3(1):9-19.
28. Anitua E, Alkhraisat MH, Orive G. Novel technique for the treatment of the severely atrophied posterior mandible. Int J Oral Maxillofac Implants. 2013 Sep-Oct;28(5):1338-46..
29. Arora V, Rao J, Singh SV, et al. An In Vivo 24-Month Study to Compare Crestal Bone Loss and Pocket Depth of Platform-Switched Implants Placed in Maxillary Anterior and Mandibular Posterior Regions. J Prosthodont. 2016 Jul;25(5):371-4.
30. Podaropoulos L, Veis AA, Trisi P, Papadimitriou S, et al. Bone reactions around dental implants subjected to progressive static load: an experimental study in dogs. Clin Oral Implants Res. 2016 Jul;27(7):910-7.
31. Turner PS, Nentwig GH. Evaluation of the value of bone training (progressive bone loading) by using the Periotest: A clinical study. Contemp Clin Dent. 2014 Oct;5(4):461-5.
32. Falisi G, Galli M, Velasquez PV, et al. Implant stability evaluation by resonance frequency analysis in the fit lock technique. A clinical study. Ann Stomatol (Roma). 2013 Jun 25;4(2):196-203.
33. Khorshid HE, Hamed HA, Aziz EA. The effect of two different immediate loading
34. protocols in implant-supported screw-retained prostheses. Implant Dent. 2011
35. Apr;20(2):157-66.
36. Juboori MJA, Attas MAA, Gomes RZ, Alanbari BF. Using Resonance Frequency Analysis to Compare Delayed and Immediate Progressive Loading for Implants Placed in the Posterior Maxilla: A Pilot Study. Open Dent J. 2018 Oct 18;12:801-810.
37. Okumura N, Stegaroiu R, Kitamura E, et al. Influence of maxillary cortical bone thickness, implant design and implant diameter on stress around implants: a three-dimensional finite element analysis. J Prosthodont Res. 2010 Jul;54(3):133-42.
38. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. J Prosthet Dent. 2003 Aug;90(2):121-32.
39. Sheridan RA, Decker AM, Plonka AB, Wang HL. The Role of Occlusion in Implant Therapy: A Comprehensive Updated Review. Implant Dent. 2016 Dec;25(6):829-838.