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REVIEW ARTICLE

BONE DENSITY IN IMMEDIATE, DELAYED AND PROGRESSIVE IMPLANT LOADING PROTOCOLS IN MAXILLARY POSTERIOR REGION

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ABSTRACT

Aim: Which of the following amongst Immediate, Delayed, Progressive Implant loading protocol is better for implant placement in the maxillary posterior region?

Materials and Methods: A systematic review of articles selected from MEDLINE, Ebscohost and Google Scholar was carried out. Additional studies were hand searched. All articles that were published in English or those having detailed summary in English were included. Only those articles that were published between 1st January 1985 and 30th September 2016 were considered. Randomized controlled trials and case studies were included with data on bone density in Immediate, Delayed and Progressive Implant Loading protocols.

Results: A total of 54 articles were identified through electronic database searching. 51 articles were obtained after elimination of duplicates which were then screened. 10 full-text articles were accessed for eligibility criteria. 8 trials were identified for inclusion in this review. (Six papers were identified on immediate loading, One paper on delayed loading, Two papers on progressive loading.)This review gives an insight about the different implant loading protocols to assess the bone level changes and bone density in the posterior region of the maxilla.

Conclusions: It is possible to load implants successfully in the posterior region of the maxilla using Immediate or Delayed or Progressive Implant loading protocols. Primary implant stability is an important factor for a successful loading procedure. At this stage, it is difficult to draw conclusions concerning the eligibility criteria's, the implant stability, bone density and bone quality needed. Clinical trials with larger samples in which the confounding factors are controlled is necessary to evaluate our finding.

Limitations: Certain studies do not give concrete conclusions due to the failure of implants, bone quality and bone quantity needed, smaller sample sizes, availability of relevant articles in different languages other than English.

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INTRODUCTION

Patients' level of understanding and demands for treatment requiring dental implants in recent times have exceeded enormously. (Roccuzzo *et al*., 2009) The success of oral implantology treatment largely focuses on treatment planning, patient factors, surgical factors, prosthodontic and procedural aspects of implant restoration. (Van de Velde *et al*., 2010) Use of simple protocols and cost effective methods are drivers to clinical implant dentistry needs. (Hinze *et al*., 2010) Today, different treatment modalities that consider severely atrophied posterior maxilla pose a challenge, while various techniques are evolving for augmenting available bone. (Esposito *et al*., 1998; Cricchio and Lundgren, 2003; Nkenke *et al*., 2001) There is a high survival rate when implants in a full arch prosthesis case are loaded immediately after placement while rehabilitating an edentulous maxilla. (Castellon *et al*., 2004; Maló *et al*., 2003; Maló *et al*., 2005) However, some factors limit the reconstruction of edentulous patients such as bone loss and anatomical structures namely the maxillary sinus or the mandibular nerve and often require bone grafting procedures which may be accompanied with increase in cost, morbidity and poor patient acceptance. (Crespi *et al*., 2012) Branemark reputed the surgical protocol in which an implant after placement was submergedand was maintained for 4 to 6 months in a non-loaded implant surrounding. During the healing period, the patients were instructed not to use the dentures for 2 weeks the and increase the use of a removable partial denture or complete denture. (Cricchio and Lundgren,

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2003) Conventionally, before the implants were placed, the infected teeth or the teeth with poor prognosis were extracted and the extraction sockets were allowed to heal for a period of 6 to 9 months at least. (Esposito *et al*., 2010; Bhola *et al*., 2008) Delayed implants can be placed with stability in mature bone. Periodontal or peri-apical infections are eliminated once the teeth are extracted hence the complications maybe minimized. (Heinemann *et al*., 2013) In 1980, Carl E. Mischintroduced the concept of progressive or gradual bone loading that suggests gradual loading causes bone maturation, improves bone density and quality, decreases crestal bone loss and early implant failure. (Misch, 2005) After the placement of implant through the first year of implant function, crestal bone loss in peri-implant was reported to be 0.9 to 1.6 mm and the mean annual bone loss decreasesd to as much as to 0.05 to 0.13 mm. In 1996 and 2005, Appleton *et al*. conducted a study and stated that crestal bone loss was reduced by progressive implant loading and bone density improved over a period of time. (Appleton *et al*., 2005; Siadat *et al*., 2012) Manz stated that after successful osseointegration crestal bone loss was said to be directly related to the bone density. (Manz, 1997)

A study on progressive implant loading protocols was carried out by Roberts *et al*. (1989) and Misch (1999 b) illicited the load on a dental implant by calculating the size of the occlusal table, the firmness of diet, direction and location of occlusal contacts.Barone *et al*. analyzed and compared the bone density in immediately loaded and unloaded implants by using a volumetric radiographic assessment method and stated that the measurements of densitometric profile for bone density was a suitable method. (Appleton *et al*., 2005) In 2002, at the World Congress Consensus Meeting in Barcelona, the theory of immediate implant loading protocol was defined along with the exact indications and criterias required for it. (Aparicio *et al*., 2003) After this meeting, Immediate loading is defined as a treatment protocol, when implants have been placed in the bone and have been restored with the use of restorations with occlusal contacts within 3-4 days after surgery. (Romanos *et al*., 2010) The essential measures to be taken into account foran immediate implant placement are debridement of the extraction socket, curettage of the bone, administration of antibiotics post surgery, and if required guided bone regeneration to seal the bone-implant gap. (Waasdorp *et al*., 2010; Quirynen *et al*., 2007) The theory of Platform switching has been introduced in the recent times and shows almost no bone resorption after the loading of immediate and delayed implants. (Heinemann *et al*., 2010) Jaffin and Berman (1991) were the first to describe the high rate of implant loss in type 4 bone, as often found in the posterior maxilla with a thin cortex and low trabecular density. Based on this assumption, several authors have suggested a thorough careful assessment of the bone prior to surgery in the posterior region of the maxilla must be donebefore the placement of implants to avoid any complications. To predict bone quality and expected initial implant stability Ikumi and Tsutsumi (Jaffin and Berman, 1991) advocated the use of a routine preoperative computed tomography (CT) for examination. Shapurian and co-workers (Shapurian *et al*., 2006) said that in situations where the quality of the bone is suspected to be poor, knowledge of the Hounsfield value can enable the surgeon to assess the density of bone, which could result in an alteration of the surgical technique or healing time. Turkyilmaz *et al*. (2007) observed that bone density is the least in the posterior region of maxilla (455 ± 122 HU), and about half of the density in the anterior region of mandible (945 ± 207 HU). The purpose of this systematic review was to evaluate and compare the Bone Density and Bone Level of Immediate, Delayed and Progressive Implant loading protocols in Maxillary Posterior region and to investigate which of the following amongst Immediate, Delayed, Progressive Implant loading protocol is better for implant placement in the maxillary posterior region.

MATERIALS AND METHODS

Component	Description
Participants	Patients treated with Implants placed in the posterior region of the maxilla.
Intervention	Implant Loading Protocol
Comparison	Immediate, Delayed, Progressive Implant loading protocols
Outcome	Bone level and Bone density
Study Design	Clinical Trials and Case Series

Eligibility criteria

Inclusion Criteria

1. Articles published in English or those having detailed summary in English.
2. Studies published between 1st January 1985 and 30th September 2016.
3. Randomized controlled trials and Case Series with data on Implant loading protocols
4. Studies that provide information about cases treated using Immediate, Delayed or Progressive Implant loading protocols.
5. Studies that provide information about the Bone Density and Bone changes in Immediate, Delayed or Progressive Implant loading protocols.

Exclusion Criteria

1. Reviews, case reports, Letters to editors, editorials and Finite Element Analysis studies are excluded.
2. Diseased Population.

Information sources

PubMed and Google scholar were the two databases used to complete the search for all full text articles available. All cross reference lists of the articles selected were screened for additional papers that could meet the eligibility criteria of the study. The search was done for studies published from 1st January 1985 to 30th September 2016.

Study selection

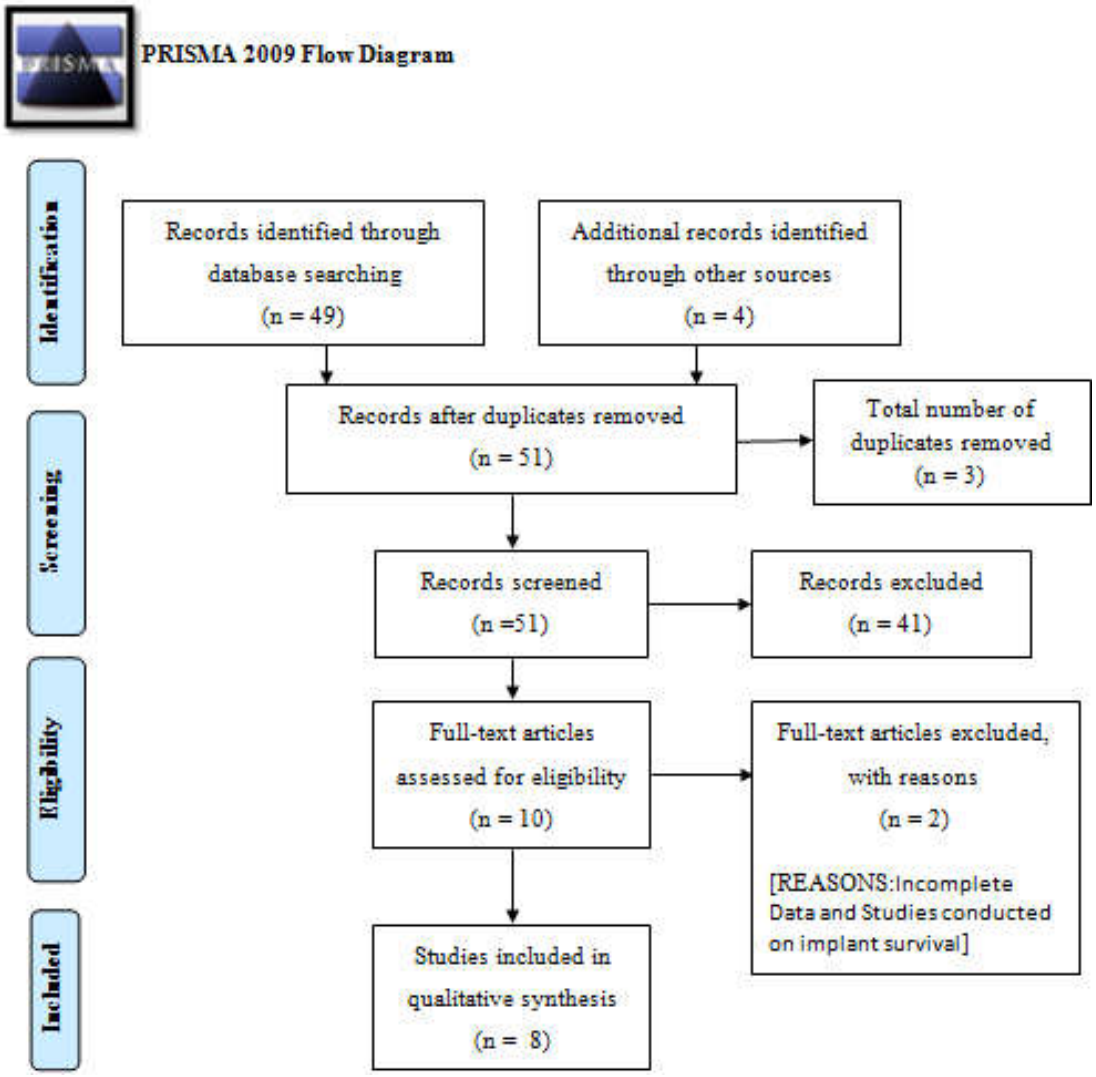
All the articles were searched using the mentioned search strategy. In the first step, titles and abstracts were screened to identify full text articles pertaining to bone density and bone level changes amongst immediate, delayed and progressive implant loading protocol in maxillary posterior region. In the second step of the screening, the duplicate articles from the respective searches were eleminated. In the third step, these articles were subjected to the inclusion and exclusion criteria's of the review.

Data collection process

Relevant data from the selected articles was recorded for the three loading categories Immediate, Delayed and Progressive

implant loading protocol in the posterior maxillary region. A standard pilot form in excel sheet was initially used and then all those headings not relevant for the review were removed. Data extraction was done for one article and this form was then reviewed by an expert and finalized. This was followed by data extraction for all the other selected articles.

RESULTS



Summary of evidence

Of the 10 papers selected for the full-text analysis, 2 were excluded because the data given in 1 paper was incomplete and other paper conducted studies on implant survival.

Immediate Loading

Six papers were identified and included. Five of them were RCTs. And only 1 was a case series. Van de Velde *et al*. (2010) in 2010 conducted a clinical and radiographic study where a randomized split-mouth design was used, where implants were placed on one side of the maxillary arch using a flapless surgery along with a stereolithographic surgical guide and on the other side of the maxillary arch implants were placed using the traditional protocol and were loaded after 6 weeks of healing. 70 implants were placed in 14 individuals using Straumann SLA implants. 3 months laterthe survival rate was found to be 97.3% for the test implants because one implant was lost and for the control group implants the survival rate was found to be 100%. Marginal bone levels were not noticeably different between the test group and control group at baseline level, the marginal bone level was said to be extensively lower as compared to the other evaluation periods.The height of the attached mucosa showed changes and was observed at the implant site that was treated using the conventional protocol.

Rismanchian *et al*. (2011) in 2010 conducted a prospective study where Twenty Astra Tech implants, were placed in the posterior region of the maxilla and mandible in 10 healthy individuals with sufficient alveolar bone. After 13 weeks functional fixed prostheses were fabricated post operatively. The success rate was found to be 100% within 1 year. The probing depth, plaque and bleeding indices did not show a major change. According to the Freidman test, the mean crestal alveolar bone loss values and the marginal alveolar bone loss changes was found to be insignificant.

Crespi *et al*. (2012) in 2012 carried out a clinical study in 36 individuals severe atrophy of the posterior region of the jaw and they were completely edentulous or partially edentulous in one or both arches of the jaw. Acrylic resin or Cast metal framework definitive prosthesis were given to the selected individuals. Upto 36 months, follow up visits and radiographic assessment of bone levels around the implant were done.

Table 1. Selected Articles on Immediate Implant Loading in Posterior Maxilla

Study	Study Design	Implant Surface	No. of Patients included	No. of Implants placed	Site	Max. Evaluation Time	Radiograph Method	Assessment Method	Result	Outcome
Van de Velde et al (2010)	RCT	SLA	14	70	Partially edentulous maxilla	18 months	Periapical radiograph (software Image J)	Marginal Bone level (Bone Height)	Baseline: 0.95 ± 0.6mm Follow up: 1.95 ± 0.7mm	Implants can successfully integrate in the posterior maxilla using a flapless approach with immediate loading similar to a conventional protocol. 2. The mucosal tissues around implants placed with a conventional flap changed significantly compared with flapless placed implants.
Mansoor et al (2010)	Case Series	Astra Tech	10	20	Partially edentulous maxilla	12 months	Periapical radiograph (Cygnus media software)	Marginal Bone Resorption	Baseline: 0mm Follow up: 0.48 ± 0.21mm	One-stage surgery and INFL with a proper patient selection, a conservative surgery, application of proper implants, and elimination of macro-design, macro-motion, micro-design, and micro-motion might lead to appropriate results.
Roberto et al (2012)	RCT	PAD system	36	Axial : 48 Tilted :48	Completely edentulous maxilla	36 months	Panoramic radiograph (CDR)	Crestal Bone Loss	Axial Follow up: 1.10 ± 0.45mm Tilted Follow up:1.11 ± 0.32mm	The same clinical outcome was seen for patients treated with the so called "All on Four protocol", regardless of wether the acrylic resin restorations were reinforced with metal.
Pozzi et al (2012)	RCT	Nobel Biocare	27	Axial : 39 Tilted :42	Partially edentulous maxilla	36 months	Periapical radiograph (Scion Image)	Marginal Bone Loss	Axial Follow up: ± 2.8mm Tilted Follow up: ± 1.96mm	Treatment of the partially edentulous atrophic maxilla with guided surgery and immediate loading of tilted and straight implants suporting short span fixed partial dental prosthesis is efffective. 2. CAD/CAM protocol for rehabilitating the posterior atrohic maxilla is a viable and minimally invasive technique for sinus floor augmentation.
Heinemann et al (2013)	RCT	tioLogic	58	136	Completely edentulous maxilla	12 months	Panoramic radiograph (STATA/MP)	Marginal Bone Loss	Baseline: ± 32mm Follow up: - 0.06mm	Immediate placement of these platform-swiched implants can be considered a reliable treatment option if stable insertion in the remaining alveolar bone beyond the original root apex is possible. 2. Overall, the mean crestal bone loss was very low with no differences between immediate and delayed implant placement.
Ostman et al (2005)	RCT	TiUnite, Nobel Biocare	20	123	Completely edentulous maxilla	12 months	Periapical Radiograph	Marginal Bone Loss	Immediate Baseline: ± 32mm Delayed Baseline: ±0.02mm Immediate Follow up: - 0.06mm Delayed Follow up: -0.10mm	The use of six to seven implants for immediate loading of a fixed provisional bridge is a viable option for implant treatment of the edentulous maxilla, at least when good primary implant stability can be ensured.

Table 2. Selected Articles on Delayed Implant Loading in Posterior Maxilla

Study	Study Design	Implant Surface	No. of Patients included	No. of Implants placed	Site	Maximum Evaluation Time	Radiographic Method	Assessment Method	Result	Outcome
Heinemann et al (2013)	RCT	tioLogic	58	136	Completely edentulous maxilla	12 months	Panoramic radiograph (STATA/MP)	Marginal Bone Loss	Baseline: ± 0.02mm Follow up: -0.10mm	1. Immediate placement of these platform-switched implants can be considered a reliable treatment option if stable insertion in the remaining alveolar bone beyond the original root apex is possible. 2. Overall, the mean crestal bone loss was very low with no differences between immediate and delayed implant placement.

Table 3. Selected Articles on Progressive Implant Loading in Posterior Maxilla

Study	Study Design	Implant Surface	No. of Patients included	No. of Implants placed	Site	Maximum Evaluation Time	Radiographic Method	Assessment Method	Result	Outcome
Appleton R et al (2004)	RCT	HA coated	20	23	Partially edentulous maxilla	12 months	Periapical Radiograph (CADIA procedure)	Crestal Vertical Bone Loss	Follow up: 0.2 ± 0.27mm	The peri-implant bone around progressively loaded implants demonstrates less crestal bone loss than the bone around implants placed conventionally into full function. 2. The peri-implant density measurements of the progressively loaded implants show continuous increase in peri-implant bone density by time.
Ghoveizi R et al (2013)	RCT	Astra Tech	10	20	Partially edentulous maxilla	12 months	Periapical Radiograph (Eigentool)	Crestal Bone Loss Bone Density	Crestal Bone Loss Follow up: ± 0.19mm Bone Density Crestal : ± 10.18mm Bone Density Middle: ± 13.17mm Bone Density Apical: ± 15.14mm	The progressive group showed less crestal bone loss in single osseointegrated implant than the conventional group. 2. Bone density around progressively loaded implants showed increase in crestal, middle and apical areas. 3. Gradual loading led to the stimulation of bone growth and maturation.

The overall 3 year survival rate was said to be 100% for axially positioned implants and 96.59% for tilted implants. The survival rate of implants was found to be 98.96% in the maxillary arch and 97.5% in the mandibular arch. The tilted and axial implants placed in either of the arches showed insignificant difference in terms of crestal bone loss.

Pozzi *et al*. (2012) in 2012 conducted a prospective study in 27 individuals with severe atrophy of the maxillary posterior region of the jaw using guided surgery with immediately loaded axial implants and CAD/CAM zirconia and titanium abutments intilted implants. The drilling protocol in bone density of each implant required an insertion torque ranging between 40Ncm and 50Ncm. A torque of 35Ncm was applied to tighten the prosthetic screwswhile the zirconia or titanium CAD/CAM customized abutments were fixed to the implants. After a period of 1 and 3 years, the implant and prosthesis survival rate wasclinically and radiologically assessed and the marginal bone remodeling of axial and tilted implants was compared at baseline.After 3 years, the implant survival rate was found to be 96.3%. All the restorations showed a survival rate of 100% and were intact and in function. The prosthetic success rate diminished to 91.9% as the veneer material of three restorations had chipped.

Heinemann *et al*. (2013) in 2013 carried out a study to evaluate the immediate placement platform-switched implants. 136 implants were placed in 58 individuals using either an immediate or delayed implant protocol. The bone level changes of the implants was measured bothon the mesial and distal aspect and during the first year no significant difference was seen in immediate and delayed implants. Subsequently no bone resorption was noted.

Ostman *et al*. (2005) in 2005 carried out a study to enhance the primary stability using a surgical protocol where 123 oxidized implants were placed in 20 individuals. Clinical and radiographic assessments were done. Out of 123 implants in the study group, 1 implant failed while no implant was lost in the reference group. The survival rateof immediate loading protocol after 12 months was 99.2% and that of delayed loading protocol was 100%. The marginal bone loss was found to be 0.78 in the study group and 0.9 in the reference group.

Delayed Loading

One paper was identified and was a RCT.

Heinemann *et al*. (2013) in 2013 carried out a study to evaluate the immediate placement platform-switched implants. 136 implants were placed in 58 individuals using either an immediate or delayed implant protocol. The bone level changes of the implants was measured both on the mesial and distal aspect and during the first year no significant difference was seen in immediate and delayed implants. Subsequently no bone resorption was noted.

Progressive Loading

Two papers were identified and included. Both of them were RCTs.

Appleton *et al*. (2005) in 2004 performed a clinical study where 23 HA-coated, endosseous dental implants were placed in 20 individuals and before surgical uncovering a healing period of 5 months was indicated. The control group underwent conventional healing while the experimental group implants underwent a progressive loading protocol. Using a progressively loading protocol, for the first 2 months the crowns were placed out of occlusion, for the next 2 months in light occlusion, and for the next 2 months in full occlusion. Radiographs of each implant were made. Using digital image analysis and digital subtraction radiography, crestal bone height changes and peri-implant bone density were measured. In the progressively loaded group of implants an increase in bone density in the crestal area was noted as compared to the conventionally loaded group, while an increase in bone density was observed at the apex of the implants in the conventionally loaded group of implants.

Ghoveizi *et al*. (2013) in 2013 conducted a study in which 23 micro thread implants were placed in 10 patients. 1 micro thread implant was assigned to the progressive loading group and another micro thread implant to the conventional loading group. Computer radiography was advised for implants placed under both progressive and conventional groups. Image analysis was done to evaluate the height of crestal bone loss and bone density. The progressively loaded implants showed an increase in bone density as compared to the conventionally loaded groups.

Conclusion

It is possible to load implants successfully in the posterior region of the maxilla using Immediate or Delayed or Progressive Implant loading protocols. Primary implant stability is an important factor for a successful loading procedure. When Progressive implant loading protocol is followed, the amount of crestal bone loss is less as compared to Immediate and Delayed implant loading protocols while peri-implant bone density shows a continous increase with progressive loading. Platform-switched implants when placed immediately show very low crestal bone loss with almost no difference between Immediate and Delayed implant placement. At this stage, it is difficult to draw conclusions concerning the eligibility criteria's, the implant stability, bone density and bone quality needed. Clinical trials with larger samples in which the confounding factors are controlled is necessary to evaluate our finding.

Implication for research

Studies with larger sample size and long term follow up may be carried out to derive our finding or to evaluate which of the three loading protocols - Immediate, Delayed and Progressive is better for implant placement in the posterior region of the maxilla.

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