Implant Loading Protocols for Partially Edentulous Maxillary Posterior Sites

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Purpose: *To evaluate early and immediate loading of implants in the posterior maxilla and to investigate whether there is a difference in success rates, survival rates, and peri-implant parameters, including marginal bone level changes.* ***Materials and Methods:*** *A comprehensive systematic review of the literature was conducted. The selection of publications reporting on human clinical studies was based on predetermined inclusion criteria and was agreed upon by two reviewers.* ***Results:*** *Twelve papers were identified on early loading (two randomized controlled clinical trials [RCTs] and 10 prospective case series studies). Six papers were found on immediate loading (one RCT, four prospective case series, and one retrospective study).* ***Conclusions:*** *Under certain circumstances it is possible to successfully load dental implants in the posterior maxilla early or immediately after their placement in selected patients. The success rate appears to be technique sensitive, although no study has directly assessed this. A high degree of primary implant stability (high value of insertion torque) and implant surface characteristics play an important role. It is not possible to draw evidence-based conclusions concerning contraindications, threshold values for implant stability, bone quality and quantity needed, or impact of occlusal loading forces. As for the impact of the surgical technique on implant outcome in different bone densities, no studies prove significant superior results with one technique over another. Well-designed RCTs with a large number of patients are necessary to make early/immediate loading protocols in posterior maxilla evidence based, but ethical and practical considerations may limit the real possibility of such studies in the near future.* INT J ORAL MAXILLOFAC IMPLANTS 2009;24(SUPPL):147–157

Key words: *dental implants, fixed dental prostheses, loading protocol, partial edentulism, posterior maxilla, single crown, systematic review*

Patients' levels of knowledge and expectations for treatment with dental implants have increased tremendously in recent years. Successful modern therapy can no longer be judged simply by whether implants osseointegrate.

Historically, it has been proposed that implants require a two-stage surgical protocol and an extended load-free healing phase for successful tissue integration. To minimize the risk of failure, the healing period in the maxilla was originally proposed to be 6 months.[1] Since then, the introduction of new implant surfaces has made it possible to modify loading protocols, although the prerequisites for achieving good results and the limitations of such protocols are not yet known. A number of articles have provided evidence that survival outcomes of implants loaded early in posterior regions are similar to those of implants placed in anterior sites under standard protocols. Therefore, it would be useful to assess whether the healing period could be shortened without jeopardizing implant success rates, even in areas of low bone density.

Jaffin and Berman[2] first described the high rate of implant loss in type 4 bone, with a thin cortex and low trabecular density, as is often found in the posterior maxilla. Interestingly, the presence of type 4 bone was described not only in the maxilla and in the posterior mandible, but also in the area anterior to the mental foramina. The authors concluded that knowledge of the presence of type 4 bone prior to surgery can lead to an alternative treatment plan, possibly one that does not include implants. Drago[3] found that successful osseointegration was most dependent on

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anatomical location in the jaws, as posterior maxillary implants placed according to the Brånemark protocol failed 28.6% of the time. On the other hand, a year later Bahat[4] found that the failure rate of similar implants placed in type 4 bone was only slightly higher than that in type 2 and type 3 bone, even though not all patients were considered good candidates for implants in the posterior maxillae. Type 4 bone was also found in sites corresponding to the premolar region.

It must be noted, however, that the possibility of reliable, clinically practical differentiation between the various types of bone has been questioned by Trisi and Rao.[5] Nevertheless, many recent studies have presented data that differentiate among the four bone types. A recent consensus paper[6] questioned the validity of the Lekholm and Zarb[7] classification and its additional ability to determine bone quality. The negative influence of low-density bone in the maxilla was also confirmed in a recent study by Herrmann and associates.[8] Post-hoc analyses confirmed that type 4 jawbone exhibited the highest failure rate.

Based on the assumption that placement of implants in the maxillary molar region requires considerably more caution in terms of performing the surgery, several authors have suggested a thorough evaluation of the bone prior to surgery in this region. Ikumi and Tsutsumi[9] advocated the use of a routine preoperative computed tomography (CT) examination to predict bone quality and expected initial implant stability. Shapurian and coworkers[10] stated that knowledge of the Hounsfield value can provide the surgeon with an objective assessment of the bone density, which could result in modification of the surgical techniques or extended healing time, especially in situations where poor bone quality is suspected. Turkyilmaz et al[11] observed that bone density is lowest in the posterior maxilla (455 ± 122 HU), and about half of the density in the anterior mandible (945 ± 207 HU). More recently, Turkyilmaz and McGlumphy[12] concluded that there is a lower threshold value of bone density for early loading and that "early loading of dental implants may be possible in sites where bone density is over 528 HU." A common assumption is that a pretreatment CT examination is always cost-effective, even though no scientific evidence definitively supports the claim.

Resonance frequency analysis has been proposed to measure implant stability based on the capacity to identify differences in bone density at the recipient sites.[13]

Many papers in the literature define bone quality as equivalent to bone density. Nevertheless, it was recently pointed out during the European Academy of Osseointegration (EAO) Consensus Meeting[6] that many factors are important when investigating bone quality other than bone density alone (eg, bone metabolism, cell turnover, mineralization, maturation, intercellular matrix, and vascularity). These factors, and possibly others, may well influence implant survival, especially in the context of immediate or early loading.

The 2003 ITI Consensus Conference proposed that "in the partially dentate maxilla and mandible, the immediate restoration or loading of implants supporting fixed prostheses is not well documented. In contrast, the early restoration or loading of titanium implants with a roughened surface supporting fixed prostheses after 6 to 8 weeks of healing is well documented and predictable in the partially dentate maxilla and mandible."[14] No clinical recommendations were given for immediate restoration or loading in the edentulous or partially dentate maxilla. For early restoration or loading in the partially dentate maxilla, the ITI Consensus recommended a fixed prosthesis: "Implant number and distribution are dependent on patient circumstances, including bone quality and quantity, number of missing teeth, condition of opposing dentition, type of occlusion, and bruxism. Implants must be characterized by a rough titanium surface and are allowed to heal for at least 6 weeks and in type 1, 2, or 3 bone."[14]

Since then, several systematic reviews on immediate and early loading protocols[15–20] have been published. All of these attempted to compare conventional with early and immediate loading protocols by analyzing the outcomes of selected clinical studies. Each of these reviews, however, was based on the selection and inclusion of a number of articles with great variability in intraoral implant location (maxilla versus mandible, anterior versus posterior), local oral conditions, implant systems used, type of prosthesis, etc, thus introducing the possibility of inconsistent interpretation of the outcomes.

Moreover, selection criteria varied from author to author. Attard and Zarb[15] searched for articles in English in MEDLINE and manually, but did not clearly state their selection procedure. They divided the studies into three categories: *(1)* fixed prostheses, *(2)* single crowns, and *(3)* overdentures. Ioannidou and Doufexi[16] as well as Del Fabbro et al[17] included various types of studies, while Nkenke and Fenner[18] based their analysis on prospective controlled studies and prospective studies without controls. Jokstad and Carr[19] decided to include only clinical trials that attempted to compare early or immediate loading of implants versus a delayed procedure and that incorporated any element of time (ruling out cross-sectional studies). Only Esposito and colleagues[20] limited the analysis to randomized controlled clinical trials (RCTs), based on the assumption that this type of

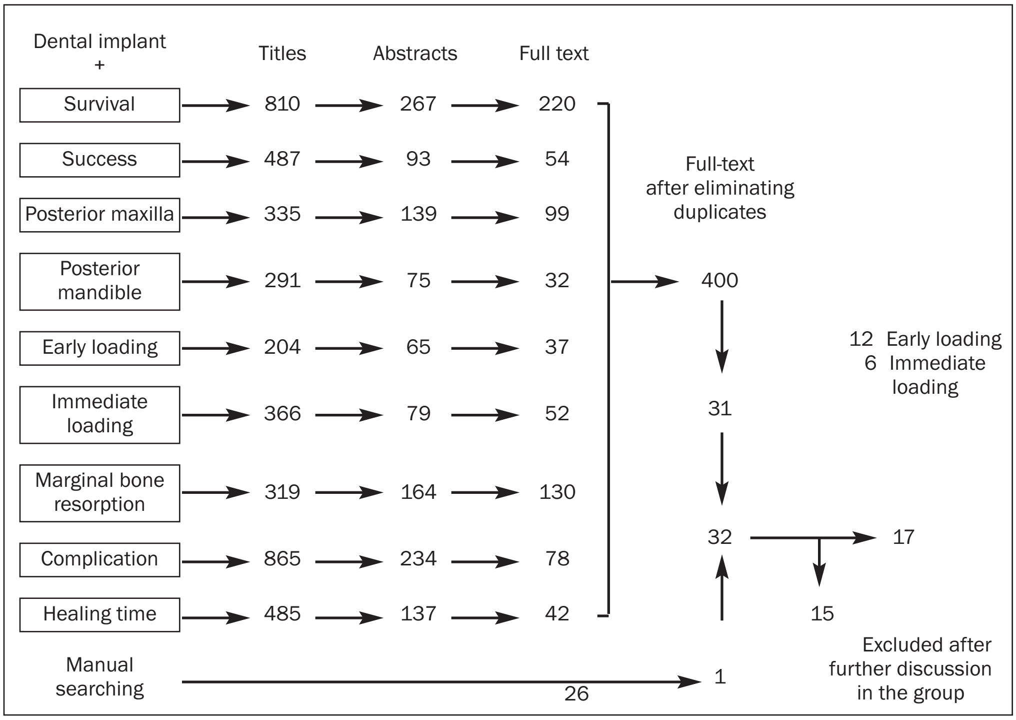

Fig 1 Search strategy for early and immediate loading protocols in posterior sites.

study presents the highest level of evidence. It is worth noting that, according to the Cochrane Collaboration protocol, both published and unpublished articles were included. As a result, the comparison between immediate and early loading was based on a meta-analysis of only two short-term, unpublished RCTs. In the present authors' opinion it is debatable whether data from a limited number of RCTs are more significant than data from a wider range of studies, such as case series with a large sample size. In any case, results have to be interpreted with caution.

Since uniformly accepted time frames for various loading protocols have not been unequivocally defined, different authors present "personal" definitions of "immediate" loading.[21] For example, recent research involving immediately loaded implants restored with crowns 4 days after surgery in dogs concluded that it was "unlikely that different results would have been obtained if the crowns were connected earlier."[22] In one of the above-mentioned reports it was acknowledged that "future research and clinical experience with peri-implant tissue healing may provide more appropriate definitions."[14] In the present authors' opinion, however, a universally acceptable definition would only be reachable through consensus by a conference of experts. It would certainly be an auspicious occasion to create a common platform on which to interpret various protocols and achieve a worldwide consensus.

To increase the possibility of achieving excellent primary stability, various clinical techniques have been suggested, such as the under-preparation of the implant site,[23] the use of a non-occluding temporary prosthesis during the first 2 months of healing,[24] the preparation of the implant site by means of osteotomes,[25–27] or the progressive loading of a prosthesis.[28]

While the success of immediately loaded implants in the mandible has been well documented, less evidence is available regarding the efficacy of early or immediate loading of maxillary implants, especially in the posterior region.

The aim of this systematic review was to evaluate the predictability of early and immediate loading protocols for implants in the posterior maxilla and to investigate whether there is a difference in success rates, survival rates, and peri-implant parameters, including marginal bone level changes, between the respective protocols. The loading definitions established by the 2003 ITI Consensus Conference were used for this review.[14]

MATERIALS AND METHODS

Search Strategy and Procedures (Fig 1)

A critical review of the literature including pertinent articles published in English was conducted. The most recent electronic search leading to this paper was undertaken on May 1, 2008.

Searching was performed using the electronic database MEDLINE (PubMed). Key words used in the search included: *dental implants, early loading, healing time, immediate loading, posterior maxilla, marginal bone resorption, complications, success rate,* and *survival rate*.

A hand search of the following journals for publications from 1991 to present was also conducted: *Clinical Oral Implants Research, International Journal of Periodontics & Restorative Dentistry, Journal of Periodontology, Journal of Clinical Periodontology,* and *International Journal of Oral & Maxillofacial Implants*.

Bibliographies from selected articles, the proceedings of the second (1997) and third (2003) ITI Consensus Conference, the position papers of the American Academy of Periodontology, and the Proceedings of the Third European Workshop on Periodontology (1999) were screened as well.

All levels of hierarchy of evidence, except for expert opinions, were accepted. Only studies with 10 or more cases in the posterior maxilla, reporting outcomes at 12 or more months, were accepted. If multiple papers included the same population, only the most recent one was used. The search was limited to studies involving human subjects published in English that included the evaluation of various healing times between surgery and loading.

Outcome measures were survival rate, success rate, and marginal bone loss.

Data Collection and Analysis

Titles and abstracts obtained through the described search were screened by two independent reviewers (Marco Aglietta, Ferruccio Torsello). The screening was performed using hard copies of the selected titles and abstracts, and included studies meeting the following criteria:

- Human trials
- Loading time
- Longitudinal studies
- Clinical outcomes

Articles involving implants in extraction sockets, guided bone regeneration, sinus floor elevation, zygomatic implants, and full-arch reconstructions were excluded. Full-text articles of studies with possible relevance were assessed by two reviewers (Mario Roccuzzo and Luca Cordaro). Any disagreement was discussed and resolved, and authors were contacted to provide, if possible, missing data. Two emails were attempted to each author for a request of further information.

The methodical quality of the studies was assessed to appraise:

- Method of randomization in controlled clinical trials. This was classified as *adequate* when a random number table, coin toss, or shuffled cards were used; *inadequate* when other methods of randomization such as alternate assignment, hospital number, odd/even birth date, etc, were applied; and *unclear* when the method of randomization was not reported or not explained.
- Allocation concealment in controlled clinical trials. This was classified as *adequate* when examiners were kept unaware of the randomization sequence, eg, by means of central randomization, sequential numbering, or opaque envelopes; *inadequate* when other methods of allocation concealment were used, such as alternate assignment, odd/even birth date, etc; and *unclear* when the method of allocation concealment was not reported or not explained.
- Completeness of follow-up was considered present if the number of patients was reported both at baseline and at completion of the follow-up, and if the analysis took into account the dropouts.

Significant data from the selected articles were recorded for the following two loading categories:

1. Early loading of implants placed in posterior maxillary sites
2. Immediate loading of implants placed in posterior maxillary sites

RESULTS

Of the 400 papers selected for the full-text analysis, most were excluded because they did not clearly report the applied loading protocols and/or made it impossible to separate data for the posterior maxilla from the whole sample. For a few papers, the application of inclusion/exclusion criteria was particularly difficult and became possible only after personal communication with the corresponding authors.

In the early loading group, the following publications were not included: Bornstein et al,[29] because data of interest for this review were from only 9 patients; Luongo at al,[30] which did not clearly state the location of failures; Testori et al[31] and Galli at al,[32] due to the insertion of implants in fresh extraction sockets; Fradera et al[33] because the study was described as prospective in the Materials and Methods section but retrospective in the title and it was not possible to get clarification from the publication itself or from the authors. Vanden Bogaerde et al[34] was not included because it was not possible to know the number of patients included in the specific group of interest, and Levine et al[35] placed several maxillary implants in conjunction with internal sinus augmentation using a bone-adding osteotome technique.

In the immediate loading group, the following articles were excluded: Glauser et al[36] due to the presence of cases with simultaneous guided bone regeneration; Degidi and Piattelli[37] and Matchei et al[38] because they had only nine patients in their material; and Calandriello et al,[39] Testori et al,[24,31] Galli et al,[32] and Boronat et al[40] because it was not possible to identify the number of patients included in the group of interest. Finne et al[41] presented cases including full-arch reconstructions and a combined survival rate for maxilla and mandible. Degidi and Piattelli[42] as well as Degidi et al[43] reported interesting data regarding immediate functional and nonfunctional loading of 646 and 1,005 dental implants, respectively, with significant follow-ups. Both articles had to be excluded, however, because the detailed analysis of the tables revealed that an unidentified number of implants were placed in extraction sites.

Early Loading

Twelve papers were identified and included (Table 1). Only two of them were RCTs.[44,45] The remaining 10 were prospective single-technique case series.[26,27,46–53]

Cochran et al[46] reported on a longitudinal, prospective, multicenter study of early loading of 383 sandblasted and acid-etched (SLA) implants placed in the posterior jaws of 307 patients. Of these, 44 were placed in the posterior maxilla and were allowed to heal for 42 to 63 days in classes 1 to 3 bone and for 84 to 105 days in class 4 bone prior to restoration. Patients who were heavy smokers or who had inadequate bone volume, bruxism, or immediate placement indications were excluded. No implant was lost at 1-year analysis.

Testori and coworkers[47] presented a longitudinal, prospective, multicenter early loading study of 475 Osseotite implants (Biomet 3i) placed in the posterior jaws. Of these, 123 were placed in the maxillary premolar and molar area and 2 failed to integrate, giving an estimated cumulative survival rate of 98.4% after 3 years.

Roccuzzo and Wilson[26] reported on 36 implants placed in 19 nonsmoking patients in areas corresponding to the second and third molars, using a specific surgical protocol. In order to increase initial implant stability in an area where bone has low density, drilling was limited to the minimum, and most of the site preparation was produced with osteotomes to compact and compress maxillary trabecular bone. Abutment connection was carried out at 15 Ncm after 43 days, and the implants were restored with provisional restorations. After 6 additional weeks, the abutments were torqued to 35 Ncm for definitive restoration. One implant rotated with pain at abutment connection and was subsequently removed. The other 35 implants were restored uneventfully, leading to a 1-year survival rate of 97.2%. The authors reported implant clinical indices similar to the 6-week period, and interproximal marginal bone loss was 0.55 ± 0.49 mm after 1 year of loading.

Nedir et al[48] presented a 7-year life table analysis from a prospective study on ITI implants, with special emphasis on the use of short implants loaded within 63 days. All early loaded implants, including implants 6 mm in length, resisted the applied 35 Ncm without rotation or pain.

Vanden Bogaerde and coworkers[49] published a prospective study of 31 nonsmoking, nonbruxing patients with 36 edentulous areas treated with Brånemark Mk IV implants (Nobel Biocare) provisionally restored 4 to 16 days after surgical placement. Thirty-nine implants were placed in 18 patients in the area of the premolar and first molar, with an estimated survival rate of 97.5%.

Nordin et al[50] presented the 1-year results of a 3-arm study on early loading of SLA implants. A group of 19 patients, partially edentulous in the posterior maxilla, were treated with 37 implants. The implant survival rate was 98.3%.

Sullivan et al[51] published a 5-year report on early loading of Osseotite implants 2 months after placement in the maxilla and mandible in 10 private practice centers. A total of 526 implants were placed. Of these, 123 were located in the posterior maxilla. The authors found only one implant failure.

Turkyilmaz and coworkers[52] conducted a prospective clinical and radiologic study of maxillary implants supporting single-tooth crowns using early (6 weeks) and delayed (6 months) loading protocols. Data on 10 patients who received 21 implants in premolar and molar regions revealed a survival rate of 95.2% at the 4-year follow-up.

Cochran and coworkers[53] reported on a longitudinal, prospective, multicenter study of early loading of SLA implants. A total of 706 patients were enrolled, and 1,406 implants were placed. In the final analyses, 590 patients with 990 implants met the inclusion criteria. The cumulative survival rate was 99.3% at 5 years.

Roccuzzo and coworkers[54] conducted a prospective study with split-mouth design, comparing 6-week loading of SLA implants to 3-month loading of titanium plasma sprayed (TPS) implants in 32 healthy patients. No implants were placed in the areas corresponding to the maxillary second and third molars. The results of the 5-year follow-up on 27 patients were presented in a recent paper.[44] Data regarding

Table 1 Selected Articles on Early Loading in the Posterior Maxilla

Study	Study type	Implant surface	No. of patients included	Sites	Smallest implant	No. of implants placed	No of implants loaded	Time of loading	Follow-up	Occlusal contacts	Type of prostheses	Splinted	Survival rate	Early failures	Results
Cochran et al (2002)[46]*	Pros	SLA	21	Premolars and molars‡	Ø 4.1× 8 mm	44	44	46–63 d	1 y	NR	FDP	Yes	100%‖	0	NR
Testori et al (2002)[47]	Pros	Osseotite	> 10†	Premolars and molars	Ø 8.5 × 3.75 mm	123	121	2 mo	up to 3 y	NR	SC/FDP	NR	98.4%	2	NR
Roccuzzo and Wilson (2002)[26]	Pros	SLA	19	Second and third molars§	Ø 4.1 × 10 mm	36	35	43 ± 1 d	1 y	Yes	SC/FDP	No	97.2%	1	Bone loss: 0.55 ± 49 mm
Nedir et al (2004)[48]*	Pros	SLA	> 10†	Posterior maxilla	Ø 6 × NR mm	42	42	< 3 mo	Up to 7 y	Yes	SC/FDP	Not necessarily	100%	0	NR
Vanden Bogaerde et al (2004)[49]*	Pros	TiUnite	18	No second and third molars	Ø 4 × 8.5 mm	39	39	4–16 d	18 mo	No	Multiple	Yes	97.5%	0	NR
Nordin et al (2004)[50]	Pros	SLA	19	Posterior maxilla	NR	37	NR	4–22 d	1 y	Yes	SC/FDP	Yes	98.3%	NR	NR
Sullivan et al (2005)[51]	Pros	Osseotite	> 10†	Premolars and molars	NR	123	122	2.1 ± 0.5 mo	Up to 5 y	Yes	SC/FDP	No	99%	1	NR
Turkyilmaz et al (2007)[52]	Pros	TiUnite	10	Premolars and molars	Ø 4 × 10 mm	21	21	6 wk	4 y	Yes	SC	No	95.2%	0	NR
Cochran et al (2007)[53]*	Pros	SLA	> 10†	Premolars and molars	Ø 4.1 × 8 mm	68	68	6–8 wk	Up to 6 y	Yes	NR	NR	100%	0	NR
Roccuzzo et al (2008)[44]*	RCT	SLA	13	No second and third molars	Ø 4.1 × 8 mm	22	19¶	6 wk	5 y	Yes	SC/FDP	No	100%	0	NR
Ganeles et al (2008)[45]*	RCT	SLActive	> 10†	No second and third molars	Ø 4.1 × 8 mm	52	52	28–34 d	12 mo	No	SC/FDP	No	98.1%	1	NR
Roccuzzo and Wilson (2009)[27]	Pros	SLActive	35	Molars§	Ø 4.1 × 10 mm	35	29#	21 ± 1 d	1 y	Yes	SC/FDP	No	100%	0	Bone loss: 0.22 ± 35 mm

Pros = prospective; RCT = randomized controlled clinical trial; FDP = fixed dental prosthesis; SC = single crown; NR = not reported; Ø = diameter.
*Additional specific data provided by the authors upon request.
†Data deduced from the analysis of the text.
‡No type 4 bone.
§Site preparation by combining milling and osteotome technique.
‖One spinner at the time of abutment connection.
¶Three spinners: these implants were loaded after 6 additional weeks.
#Six spinners: these implants were loaded after 4 additional weeks.

the posterior maxillary region included 13 patients with 22 implants. Of these, 19 were loaded early (at 6 weeks) while 3 exhibited "spinning" at the abutment connection. At the 60-month follow-up, all implants were in full function.

In a prospective study, Roccuzzo and Wilson[27] reported on 35 patients receiving SLActive implants (Straumann, Andover, MA, USA) in the maxillary molar areas. Preparation of implant sites with drills was limited to a minimum; most of the site preparation was produced with osteotomes. No screw-tapping was performed. Primary stability was predictably achieved with this technique. Abutment connection was carried out at 21 (± 2) days after surgery using 15 Ncm torque, and provisional restorations were delivered with occlusal contact. During abutment connection, 6 of the 35 patients reported minor pain, and provisional placement was postponed for 4 additional weeks. Further abutment tightening at 35 Ncm was performed after 4 to 6 additional weeks prior to final restoration. Radiographic measurements taken at baseline and at the 1-year follow-up revealed marginal bone loss of 0.22 ± 0.35 mm versus the immediate postoperative radiographs.

In a recent paper, Ganeles and coworkers[45] presented the 1-year results from a prospective multicenter study on immediate and early loading of SLActive implants in the posterior mandible and maxilla. No implant was placed in the position corresponding to the third molar. Patients received a temporary restoration (single crown or 2- to 4-unit fixed partial denture) out of occlusal contact 28 to 34 days later. Any patient with implants lacking primary stability, tested intraoperatively by hand, was excluded. Fifty-two implants were placed in the posterior maxilla, and the 1-year survival rate was 98.1%.

Immediate Loading

Six papers were identified and included (Table 2). Only the study of Ganeles and coworkers[45] was an RCT; four were prospective single-technique case series[55–58] and one was a retrospective study.[59]

Buchs and coworkers[55] presented a prospective multicenter study on the placement and immediate loading of 143 implants. Of these, 44 were in the posterior maxilla, but none was in the position corresponding to the third molar. The implants were followed for a period of 10 to 29 months.

Proussaefs and Lozada[56] reported on immediate loading with threaded hydroxyapatite-coated root-form implants for single first premolar replacement. Ten implants in 10 patients were followed for 3 years. Patients with a history of bruxism were excluded, as were surgical sites exhibiting type 4 bone, as assessed during surgery. Mean bone loss was 1 ± 0.26 mm.

Table 2 Selected Articles on Immediate Loading in the Posterior Maxilla

Study	Study type	Implant surface	No. of patients included	Sites	Bone quality/ primary stability	Smallest implant	No of implants placed	Restoration time limit	Follow-up	Occlusal contacts	Type of prostheses	Splinted	Survival rate
Buchs et al (2001)[55]	Pros	Altiva NTR	> 10†	No third molars		Ø 4 × 10 mm	44	< 24 h	10–29 mo	NR	NR	NR	93%–100%
Rocci et al (2003)[59]	Retr	Mk IV (machined)	> 10†	Premolars and molars	No type 4 bone	Ø 4 × 8.5 mm	67	NR	24–36 mo	NR	SC/FDP	NR	88%
Proussaefs and Lozada (2004)[56]	Pros	HA-coated	10†	First premolars	No type 4 bone	NR	10	NR	3 y	No	SC	No	100%§
Calandriello and Tomatis (2005)[57]*	Pros	TiUnite	11†	No second and third molars		Ø 4 × 10 mm	26‡	NR	1 y	Light	FDP	Yes	100%
Achilli et al (2007)[58]*	Pros	Various	10	Premolars and molars	No type 4 bone/ torque > 30 Ncm	Ø 3.5 × 10 mm	23	< 24 h	1 y	Light	FDP	NR	100%
Ganeles et al (2008)[45]*	RCT	SLActive	> 10†	No second and third molars		Ø 4.1 × 8 mm	71	NR	12 mo	No	SC/FDP	NR	97.2%

Pros = prospective; Retr = retrospective; RCT = randomized controlled clinical trial; FDP = fixed dental prosthesis; SC = single crown; Ø = diameter.
*Additional specific data provided by the authors upon request.
†Data deduced from the analysis of the text.
‡ Also tilted implants.
§ Mean bone loss: 1.0 (SD 0.26).

Rocci and coworkers[59] presented a retrospective 3-year clinical study on immediate loading in the maxilla using flapless surgery. Sixty-seven implants were placed in the posterior maxilla. No implants were inserted in areas of type 4 bone. During the 2 to 3 years of follow-up, eight implants were lost, yielding a survival rate of 88%.

Calandriello and Tomatis[57] proposed the use of tilted implants placed in immediate/early function. The prospective 1-year clinical study included 60 implants placed in 18 patients to support 19 fixed partial or full-arch prostheses. The authors provided information regarding 11 patients, who received 26 implants to support fixed partial dentures in light occlusal contact. At 1-year evaluation no implant was lost.

Achilli and colleagues[58] conducted a prospective multicenter study on immediate/early function with tapered implants involving maxillary and mandibular posterior fixed partial dentures. Data regarding immediate loading in the posterior maxilla were provided by the author, and referred to 23 implants placed in 10 patients. Implant stability was tested with a reverse torque of 30 Ncm. No implants were placed in type 4 bone. The occlusal surfaces of the provisional prostheses allowed light occlusal contact and minimal or no lateral excursive contacts. At the 1-year follow-up no implant was lost.

In a recent RCT, Ganeles and coworkers[45] presented the 1-year results of a prospective multicenter study on immediate and early loading of SLActive implants in the posterior mandible and maxilla. Data regarding immediate loading in the posterior maxilla were provided by the authors. The smallest implants used were 8 mm in length and 4.1 mm in diameter. At 12 months, the survival rate was 97.2%. A significant center effect was observed involving differences in bone level changes between immediate and early loading that were partially dependent on the center. The authors suggested that the immediate loading group was more heterogeneous. No implant was immediately loaded in positions corresponding to the second and third molars.

DISCUSSION

Several previous systematic reviews sought to test the hypothesis that there is no difference in the clinical performance of implants loaded at different times. In all cases, definitive conclusions could not be drawn concerning success rates of implants loaded immediately/early compared to conventionally loaded implants. Moreover, no information was obtainable regarding specific indications in high-risk situations, such as the posterior maxilla.

Several authors have proposed variations to implant placement techniques in order to adapt the standard surgical protocol to soft bone conditions. In these situations, therefore, one can assume that the risk of failure is increased. This review attempted to find the best available evidence relative to clinical outcomes for fixed implant-supported prostheses in the posterior maxilla under immediate/early loading protocols. Drawing definitive conclusions from the selected articles is difficult, as the articles are not directly comparable due to the diversity of inclusion criteria, treatment protocols, and defined outcomes. These are basically the same limitations Ganeles and Wismeijer[60] identified in their literature review.

One important issue is the definition of *posterior maxilla*. Traditionally, the segment of the alveolar process distal to and including the first premolar is considered posterior.[10,61] Even though this assumption seems reasonable from a prosthetic point of view, from an anatomical point of view the quality of the bone in the premolar area appears more similar to the canine region than to the posterior molar region.

Jaffin and Berman[2] were the first to notice that poor bone quantity and especially poor bone quality are the main risk factors for implant failure with standard protocols. Since then, many articles have been published with various conclusions. More recently, Ikumi and Tsutsumi[9] stated that "implants in the maxillary molar region in particular appear to have a lower osseointegration rate before loading and a lower survival rate over time as compared to other sites."

Esposito and coworkers[20] concluded that a high degree of primary stability at implant insertion is a key prerequisite for a successful immediate or early loading procedure. "The main outcome for this type of study is the success of the prosthesis, since implant loss may not always jeopardize prosthesis success." It is hard to understand why after such strict selection criteria such a broad definition of success was employed.

In two recent RCTs, Testori et al[31] and Galli et al[32] suggested that there are no major clinical differences between immediately restored non-occlusally loaded implants and early (2 months) loaded implants. However, to be immediately loaded, single implants had to be inserted with a torque of ≥ 30 Ncm, and splinted implants with a torque of ≥ 20 Ncm. In the protocol formulation phase, it was decided that implants randomized to the immediately loaded group having lower torque resistance should instead be treated as part of the early loaded group. Therefore, no conclusions can be drawn for implants in type 4 bone, as it is usually found in the posterior maxilla.

In most of the studies on early/immediate loading, good bone quality has been mentioned as an important prognostic factor, although the level of evidence that supports this assumption is limited. Moreover, no controlled clinical trial, to the best of our knowledge, has compared the relationship between different implant stability levels and the implant survival rate.

Of the six selected articles on immediate loading, three avoided areas with type 4 bone,[56,58,59] one required a minimal insertion torque,[58] one did not include the area of the third molar,[55] and two did not include the area of both the second and third molars.[45,57] All these different specific exclusion criteria make comparisons difficult. Moreover, the clinician should be aware of the risk of reproducing the loading protocols in these studies in daily practice without exercising the same exclusion criteria.

A common belief is that treatment with immediate loading improves patient satisfaction and is cost-effective, even though no scientific evidence supports this claim. This is especially true in the posterior maxilla, where early loading can include the possibility of a long-span fixed partial denture (four or five elements) supported by only two implants. However, the question of how many teeth can safely be supported by two implants is still an open one. In addition, no data are available to assess if short (< 8 mm) and/or narrow (< 3.5 mm) implants could also be included in similar protocols. Finally, limited spinning at abutment connection in the case of early loading, particularly in low-density bone, has been described in several papers. Recent publications, however, confirmed that if it is properly handled, this produces no detrimental effect on the clinical outcome.[44]

Degidi and Piattelli[42] attempted to address important questions related to immediate loading. In particular they suggested that the PU/I (the ratio between the number of prosthetic units and the number of implants) should be as close as possible to 1 and should not exceed 1.4 in the maxilla, independent of functional or nonfunctional loading. The authors further advised that every effort should be made to deliver the prosthesis on the same day as the surgery. These conclusions, however, need to be validated by future studies.

CONCLUSIONS

Under certain circumstances, it is possible to successfully load dental implants in the posterior maxilla early or even immediately after their placement in selected patients, although only skilled clinicians can achieve optimal results. The success rate seems to be technique sensitive, even though no data are available regarding this aspect. A high degree of primary implant stability (high value of insertion torque) seems to be one of the prerequisites for a successful immediate/early loading procedure. Preliminary results seem to indicate that implant surface characteristics may play an important role in the success rate of the procedure.

At this point, it is not possible to draw conclusions concerning exclusion criteria, threshold values for implant stability, bone quality and quantity needed, or impact of occlusal loading forces. As for the impact of the surgical technique on implant outcome in different bone densities, no studies prove significant superior results with one technique over another.

Well-designed RCTs with a large number of patients are necessary to make early/immediate loading protocols in the posterior maxilla evidence based, but ethical and practical considerations may limit the real possibility of such studies in the near future.

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