Marginal Bone Loss with Mandibular Two-Implant Overdentures Using Different Loading Protocols: A Systematic Literature Review

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Purpose: Mandibular two-implant overdentures opposing conventional complete maxillary dentures have been proposed as the standard for complete denture service. Monitoring marginal bone loss around implants is regarded as the most important criterion in determining the success of implants. The aim of this systematic literature review was to critically evaluate the literature on short- and long-term marginal bone loss associated with mandibular two-implant overdentures using different loading protocols. **Materials and Methods:** The MEDLINE, EMBASE, and PubMed (using medical subject headings) databases were searched using the restriction of articles in English only. Other articles were identified from the reference lists of the articles found, as well as from early online articles. Reviewed studies were those on two oral implants supporting mandibular overdentures with different loading protocols. Marginal bone loss was evaluated as well as the validity of using marginal bone loss measurements for determining the success of implants. **Results:** Twenty-five studies met the review criteria. Clinical studies involving conventional loading showed long-term results; however, early and immediate loading protocols were only in the short term. High success or survival rates of two implants supporting mandibular overdentures were reported, regardless of the loading protocol. A lack of standardization was revealed in the radiographic methods used for measuring marginal bone loss and the success criteria on which results were based. Long-term outcomes of the effect of different loading protocols on marginal bone loss were not found. Due to the wide methodologic variation among the included studies, it was difficult to compare data between studies or to determine long-term marginal bone loss patterns with this treatment. For conventional two-stage and one-stage loading protocols, the range of marginal bone loss seen in the first year was 0.2 to 0.7 mm and 0.0 to 2.0 mm, respectively. For early loading protocols, the range was 0.0 to 0.2 mm; immediate loading protocols saw a marginal bone loss of around 0.7 mm in the first year. **Conclusions:** Short-term findings indicate that so far, there is no detrimental effect on marginal bone levels with early and immediate loading protocols. However, to recommend these protocols in the long-term for two implants supporting mandibular overdentures may be premature. *Int J Prosthodont 2010;23:117–126.*

The management of complete edentulism and its sequelae with implant-supported prostheses has been reported to be both efficacious and effective.[1–3] Both fixed and overdenture clinical protocols have now expanded to include diverse loading ones in spite of the fact that there is a lack of uniformity in the determinants of successful outcome criteria. Nevertheless, mandibular two-implant overdentures opposing conventional complete maxillary dentures have been proposed as the standard of care[4] since this treatment option appears to provide higher levels of patient treatment satisfaction.[5–9] There also

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Table 1 Comparison of Success Criteria for Oral Implants*

	Radiographic examination	Marginal bone loss
Albrektsson et al[10]	No evidence of peri-implant radiolucency	< 0.2 mm annually after the first year of function
Buser et al[11]	Absence of a continuous radiolucency around the implant	Not clearly defined
Albrektsson and Zarb[12]	No evidence of peri-implant radiolucency	Mean annual loss of < 0.2 mm after the first year of function
Albrektsson and Isidor[13]	No evidence of loss of integration	Average of < 1.5 mm during the first year after insertion of the prostheses, followed by < 0.2 mm annually thereafter
Roos et al[14]	Individually radiographed and no evidence of loss of integration	< 1.0 mm in the first year, followed by < 0.2 mm annually thereafter
Zarb and Albrektsson[15]	Individual standard periapical films with specified points and angulations	Mean vertical bone loss of < 0.2 mm annually following the first year of function

*Modified from Roos et al.[14]

appears to be international support for a clinical protocol whereby two splinted or unsplinted implants in the anterior mandible will successfully support and retain a removable overdenture.[5–8]

Several criteria[10–16] are presumed to determine implant success, with marginal bone loss around implants considered to be a significant one by numerous authors.[10,12–15,17] This criterion is generally accepted as a reliable indicator of bone response to the surgical procedure and subsequent occlusal loading. It is also conceded that the response continuum may be influenced by a number of factors such as specific site response, surgical skill, the implant's micro- and macroscopic surface design, timing, and control of the occlusal loading. Early recommendations included a projected 1.0 mm of marginal bone loss during the first year of function and 0.2 mm annually thereafter.[10,12,14,15] A subsequent publication[13] extended the "permissible" marginal bone loss during the first year to 1.5 mm and added the descriptor "average," which reflected the consideration that implant success should be determined on an entire-mouth basis and not by each implant as an independent unit.

The lack of uniformity in the accepted limit of marginal bone loss as an integral part of criteria for success in implant dentistry (Table 1)[10,11,12–15] has made clinical study comparisons challenging. Recent attempts to modify the success criteria are far from compelling.[18] A noteworthy systematic review[19] stressed the issue of the variability or nondisclosure of criteria for success in publications, and further suggested that no less than 50% bone loss around implants should be regarded as successful. This statement placed marginal bone loss as the decisive factor in distinguishing between implant success and survival; however, it has also reverted to making the length of the implant more important than the actual amount of marginal bone loss. With marginal bone level employed as a key surrogate criterion for implant success,[20] the significance of differences in the acceptable limit of marginal bone loss must be resolved since this inconsistency will inevitably lead to an overestimation of success rates.

The aim of this review was to critically evaluate reported information on marginal bone loss around two implants supporting mandibular overdentures using different loading protocols and the validity of using marginal bone loss as a criterion in deciding implant success.

Materials and Methods

The PICO format (Population, Intervention, Comparisons, Outcomes)[21] was used to define a focused clinical question with clear inclusion criteria.

Specific inclusion criteria were clinical studies involving completely edentulous participants (P) requiring mandibular two-implant overdentures opposing conventional maxillary complete dentures (I). The chosen studies were then further divided according to the loading protocols (conventional, early, or immediate) that were used (C). Excluded studies were those that used loading protocols of longer than 3 months, participants with compromised medical conditions, or ones that required additional surgical interventions such as grafting. Marginal bone loss was the outcome (O) evaluated depending on the loading protocol. No restriction was placed on the minimum observation period required for a study to be included in this review.

Search Strategy

The MEDLINE (1950 to June 2008), EMBASE, and PubMed (using medical subject headings) databases were searched with the restriction of articles in English only. Keywords used during the search were "marginal bone loss," "implant overdenture(s)," "two implant overdenture(s)," "edentulous," "mandible(s)," "success criteria + implant," and "loading ± protocol(s) ± strategy(ies)." Other articles were identified from the reference lists of the articles found using the aforementioned databases. Early online articles were also examined from the following dental journals: *Clinical Implant Dentistry and Related Research, Clinical Oral Implants Research, Journal of Clinical Periodontology,* and *Journal of Periodontology*. The title and abstracts (when available) of all reports identified through the electronic search were scanned independently by the authors. For studies appearing to meet the inclusion criteria, or for which there were insufficient data in the title and abstract to make a clear decision, the full report was obtained. All the information was assessed independently by the authors to establish whether the studies met the inclusion criteria. There was a unanimous agreement between the reviewers regarding the included studies.

Results

A total of 151 articles were identified through the search methods previously described. However, only 25 met the inclusion criteria for the review. Those 25 studies based their success/survival rates for implants on different criteria, and also used different methods to measure marginal bone levels. Some studies did not report annual marginal bone loss.

The 25 studies were divided according to the loading protocols (conventional, early, or immediate)[22] that had been used.

Conventional Loading

Twenty studies[23–42] were identified as using a conventional loading protocol. Among them, 7 were classified as using a conventional two-stage loading protocol (Table 2).[23–29] Fifteen studies[25,26,30–42] used a conventional one-stage loading protocol (Table 3), of which 2 studies[25,26] had their control groups using the conventional two-stage loading protocol. Short-term studies using a conventional one-stage loading protocol were the control groups for more recent studies involving early or immediate loading protocols. The number of implants used in each study varied, with one study[29] including sleeping implants. Most studies stated the type of implant surface (smooth machined or roughened), with some[23,28,29,42] specifying the implant system but not the implant surface. Various attachment systems, such as ball attachments, bars (round or egg-shaped), telescopic crowns, and magnets, were used to support the mandibular implant overdentures.

Intraoral radiographs with a long-cone paralleling technique were the most common radiographic method used in the studies, with a few[27,36,41] using panoramic radiographs to measure marginal bone levels. Changes in marginal bone levels were measured from reference points on the implant systems, such as the implant-abutment junction to the first bone-to-implant contact. One study[28] measured marginal bone levels by marking the alveolar bone level with a straight line and then measuring the distance between that line and the first bone-to-implant contact.

The time at which the baseline radiographs were taken also varied between studies, being either at the time of implant placement,[24,30–35,42] loading,[25,29,38,40,41] a few weeks after loading,[23,26,28,39] or as late as 1 year after loading.[27] One study did not specify when the baseline radiographs were taken.[36] The success/survival rates for implants reported in studies ranged from 83% to 100%, with some based on standard implant success criteria.[10,14,16] However, one study[27] used its own scale by dividing the implant lengths into 3 and then classifying the amount of marginal bone loss accordingly. Some did not provide success/survival rates despite reporting annual marginal bone loss measurements.[23,26,28,35,36,42] One study[29] did not regard the annual marginal bone loss data as a success criterion but only as a prospective prognosis. The range of marginal bone loss seen in the first year was 0.2 to 0.7 mm for the conventional two-stage loading protocol and 0.0 to 2.0 mm for the conventional one-stage loading protocol.

Early Loading

Thirteen studies[23,30–35,37,38,41,43–45] used the early loading protocol for mandibular two-implant overdentures (Table 4). The implants in those studies were loaded as early as 5 days postoperatively. Two studies[32,43] that had titles including the terms "immediately loaded" and "immediate loading" did not coincide with their descriptions of the loading protocol, which were 1 week[32] or 10 days[43] after implant placement.

The observation periods used in the included studies ranged from 1 to 2 years, and all were prospective. The majority of studies used implants with roughened surfaces, except for one[44] that used

Table 2 Conventional Two-Stage Loading Protocol

	No. of participants/ implants	Implant system	Implant surface	Attachment system	Observation period	Baseline measurement	Radiographic method (reference point)	Marginal bone loss	Success (SC) or survival (SU) rate
De Smet et al[23]	10 / 20	Brånemark	Not specified	Ball	1–2 y	1 wk after prosthesis placement	Digital intraoral periapicals, paralleling technique (IAJ)	1 y: 0.43 mm 2 y: 0.51 mm	Not specified
Krennmair et al[24]	25 / 50	Camlog	Roughened	Ball Telescopic crown	3 y (prospective)	Implant placement	Panoramics and/or periapicals, paralleling technique (not specified)	3 y Ball: 1.9 mm Telescopic: 1.8 mm	SC: 100% SU: 100%
Meijer et al[25]	60 / 120	Brånemark IMZ	Smooth Roughened	Bar (round)	5 y (prospective)	3 mo after implant placement	Standardized intraoral radiographs[55] (fixed reference point)[56]	5 y IMZ: 1.4 mm Brånemark: 0.7 mm	SU: 98.3%
Heydenrijk et al[26]	20 / 40	IMZ	Roughened	Bar (egg-shaped)	2 y (prospective)	4 wk after prosthesis insertion	Standardized intraoral radiographs[55] (fixed reference point)[56]	1 y: 0.6 mm 2 y: 0.8 mm	SU: 97.5%
Meijer et al[27]	61 / 122	Brånemark IMZ	Machined Roughened	Bar (round)	5 y (prospective)	1 y after functional loading of implants	Panoramics (not specified)	According to the following scale: 0: No apparent bone loss, 1: < 1/3 of the implant length, 2: > 1/3 but < 1/2 of the implant length, 3: >1/2 of the implant length	SU-Brånemark: 86% IMZ: 93%
Batenburg et al[28]	90 / 180	Brånemark IMZ ITI	Not specified	Bar (round)	1 y (prospective)	4 wk after prosthesis insertion	Standardized intraoral radiographs[55] (line contacting the height of the alveolar ridge)	1 y Brånemark: 0.34 mm IMZ: 0.53 mm ITI: 0.19 mm	Not specified
Naert et al[29]	207 / 449 (22 sleeping implants)	Brånemark	Not specified	Ball Bar (egg-shaped) Magnet	Up to 9 y (retrospective)	3–4 mo after implant placement	Long-cone parallel technique (IAJ)	1 y: 0.7 mm 0.05 mm/year	SC: 97.2% (cumulative)

IAJ = implant-abutment junction.

smooth-surface implants. One study[23] failed to state the type of implant surface used in its clinical trial. Radiographic methods used to monitor the changes in marginal bone levels were consistent (standardized intraoral radiographs) except for in one study,[41] which employed panoramic radiographs. Some studies took radiographs at the time of implant placement[30,31,33,35] and used this time point as the baseline for reporting changes in marginal bone levels.

Studies reported very high success/survival rates of up to 100%; however, one study[37]reported an unacceptably low success rate of 71% for Steri-Oss (Nobel Biocare) compared to 100% for Southern Implant implants. It should also be noted that one of the prospective studies[23] based its 2-year results on only 50% of its early loading group participants. There was no justification for this method of data collection. The success/survival rates reported in these studies were based on several different success criteria,[10,14,16,17] with the range of marginal bone loss in the first year being 0 to 2 mm.

Immediate Loading

Two studies[46,47] used the immediate loading protocol for mandibular two-implant overdentures (Table 5). Both studies were prospective, reporting up to 2-year follow-up data, and used roughened-surface implants with either ball attachments or bars to support the mandibular implant overdentures. Radiographic techniques included periapical radiographs using the paralleling technique and panoramic radiographs to

Table 3 Conventional One-Stage Loading Protocol

	No. of participants/ implants	Implant system	Implant surface	Attachment system	Observation period	Baseline measurement	Radiographic method (reference point)	Marginal bone loss	Success (SC) or survival (SU) rate
Tözüm et al[30]	7 / 14	Brånemark	Roughened	Ball	18 mo (prospective)	Implant placement	Standardized intraoral radiographs[57] (IAJ)	Mean bone level: 0.92 mm	Not specified
Turkyilmaz and Tumer[31]	10 / 20	Brånemark	Roughened	Ball	2 y (prospective)	Implant placement	Standardized intraoral radiographs[57] (IAJ)	Mean bone level: 1.1 mm	SC: 100%
Turkyilmaz et al[32]	10 / 20	Brånemark	Roughened	Ball	1 y (prospective)	Implant placement	Standardized intraoral radiographs	1 y: 0.3 mm	SC: 100%[10]
Turkyilmaz et al[33]	13 / 26	Brånemark	Roughened	Ball	2 y (prospective)	Implant placement	Standardized intraoral radiographs[57] (IAJ)	1–24 mo: 0.5 mm	SC: 100%[10]
Turkyilmaz et al[34]	10 / 20	Brånemark	Roughened	Ball	1 y (prospective)	Implant placement	Standardized intraoral radiographs	1 y: 0.3 mm	SC: 100%
Turkyilmaz[35]	13 / 26	Brånemark	Roughened	Ball	12 mo (prospective)	Implant placement	Standardized intraoral radiographs[57] (IAJ)	1 y: 0.28 mm	Not specified
Meijer et al[25]	30 / 60	ITI	Roughened	Bar (round)	5 y (prospective)	3 mo after implant placement	Standardized intraoral radiographs[55] (fixed reference point)[56]	5 y: 0.9 mm	SU: 100%
Heckmann et al[36]	41 / 82	ITI	Roughened	Telescopic	8–12.8 y	Not specified	Digital panoramics (implant shoulder)	Mean bone level: 3.19 mm	Not specified
Heydenrijk et al[26]	40 / 80	IMZ ITI	Roughened	Bar (egg-shaped)	2 y (prospective)	4 wk after prosthesis insertion	Standardized intraoral radiographs[55] (fixed reference point)[56]	1 y IMZ: 0.6mm ITI: 0.6 mm	Not specified
Tawse-Smith et al[37]	24 / 48	Southern Steri-Oss	Roughened	Ball	2 y (prospective)	12 wk after implant placement	Standardized intraoral radiographs[57] (Southern: IAJ, Steri-Oss: 1 mm below IAJ)	1 y Southern: 0.16 mm Steri-Oss: 0.10 mm 1–2 y Southern: 0.00 mm Steri-Oss: 0.00 mm	SC[16] Southern: 83.3% Steri-Oss: 87.5%
Payne et al[38]	12 / 24	ITI	Roughened	Ball	2 y (prospective)	12 wk after implant placement	Standardized intraoral radiographs (implant shoulder)	1 y: 0.35 mm 1–2 y: 0.09 mm	SC: 91.6%[16]
Heydenrijk et al[39]	40 / 80	IMZ ITI	Roughened	Bar (egg-shaped)	1 y (prospective)	4 wk after prosthesis insertion	Standardized intraoral radiographs[55] (fixed reference point)[56]	1 y IMZ: 0.6 mm ITI: 0.6 mm	SU ITI: 100% IMZ: 97%
Tawse-Smith et al[40]	24 / 48	Southern Steri-Oss	Roughened	Ball	1 y (prospective)	12 wk after implant placement	Standardized intraoral radiographs[57] (Southern: IAJ, Steri-Oss: 1 mm below IAJ)	1 y Southern: 0.08 mm Steri-Oss: 0.07 mm	SC[14] Southern: 100% Steri-Oss: 95.8%
Røynesdal et al[41]	10 / 20	ITI	Roughened	Ball	2 y (prospective)	3 mo after implant placement	Panoramics (not specified)	1 y: 0-2 mm	SU: 100%
Wismeijer et al[42]	73 / 146	ITI	Not specified	Ball Bar (egg-shaped)	19 mo (prospective)	Implant surgery	Panoramics (not specified)	19 mo: 1.2 mm	Not specified

IAJ = implant-abutment junction.

Table 4 Early Loading Protocol

	No. of participants/ implants	Implant system	Implant surface	Attachment system	Observation period	Baseline measurement	Radiographic method (reference point)	Marginal bone loss	Success (SC) or survival (SU) rate
Tözüm et al[30]	8 / 16	Brånemark	Roughened	Ball	18 mo (prospective)	Implant placement	Standardized intraoral radiographs[57] (IAJ)	Mean bone level: 0.97mm	SC: 100%
Turkyilmaz and Tumer[31]	10 / 20	Brånemark	Roughened	Ball	2 y (prospective)	Implant placement	Standardized intraoral radiographs[57] (IAJ)	Mean bone level: 1.1 mm	SC: 100%
De Smet et al[23]	10 / 20	Brånemark	Not specified	Ball	1–2 y (prospective)	2 wk after implant placement	Digital intraoral periapicals (IAJ)	1 y: 1.28 mm 2 y: 1.19 mm	Not specified
Turkyilmaz et al[32]	10 / 20	Brånemark	Roughened	Ball	1 y (prospective)	Implant placement	Standardized intraoral radiographs[57] (not specified)	1 y: 0.3 mm	SC: 100%[10]
Turkyilmaz et al[33]	13 / 26	Brånemark	Roughened	Ball	2 y (prospective)	Implant placement	Standardized intraoral radiographs[57]	2 y: 0.4 mm	SC: 100%[10]
Turkyilmaz et al[34]	10 / 20	Brånemark	Roughened	Ball	1 y (prospective)	Implant placement	Standardized intraoral radiographs[57]	1 y: 0.3 mm	SC: 100%
Turkyilmaz[35]	13 / 26	Brånemark	Roughened	Ball	1 y (prospective)	Implant placement	Standardized intraoral radiographs[57] (IAJ)	1 y: 0.27 mm	SC: 100%
Attard et al[43]	35 / 70 (69 back-ups)	Brånemark	Roughened	Bar (ovoid)	1 y (prospective)	10 d after implant placement	Standardized intraoral radiographs[50,53] (implant shoulder)	1 y: 0.4 mm	SC: 98.6%
Payne et al[44]	24 / 48	ITI; Southern	Roughened	Ball	1 y (prospective)	6 wk after implant placement	Standardized intraoral radiographs[57] (ITI: Implant shoulder, Southern: IAJ)	1 y ITI Mesial: 0.18 mm Distal: 0.34 mm Southern Mesial: 0.26 mm Distal: 0.33 mm	SC[16,17] ITI: 100% Southern: 91.6%
Tawse-Smith et al[37]	24 / 48	Southern Steri-Oss	Roughened	Ball	2 y (prospective)	6 wk after implant placement	Standardized intraoral radiographs[57] (Southern: IAJ, Steri-Oss: 1 mm below IAJ)	1 y Southern: 0.12 mm Steri-Oss: 0.12 mm; 1–2 y Southern: 0.06 mm Sterioss: 0.0 mm	SC[16] Southern: 100% Steri-Oss: 70.8%
Payne et al[38]	12 / 24	ITI	Roughened	Ball	2 y (prospective)	6 wk after implant placement	Standardized intraoral radiographs (implant shoulder)	1 y: 0.27 mm 1–2 y: 0.12 mm	SC: 100%[16]
Røynesdal et al[41]	10 / 20	ITI	Roughened	Ball	2 y (prospective)	3 wk after implant placement	Panoramics (not specified)	1 y: 0-2 mm	SU: 100%
Payne et al[45]	10 / 20	Brånemark	Smooth	Ball	1 y (prospective)	2 wk after implant placement	Standardized intraoral radio-graphs (IAJ)	1 y Mesial: 0.22 mm Distal: 0.30 mm	SC: Grade I[14]

IAJ = implant-abutment junction.

monitor marginal bone levels. One study[47] concurrently monitored marginal bone levels with periapical radiographs and panoramic radiographs during the first 3 months, and then continued using panoramic radiographs for the 1- and 2-year follow-ups. The same study[47] also did not specify its reference points for measuring marginal bone loss. Both studies took baseline radiographs at implant placement.[46,47] The implant survival rates of both studies were 100% according to success criteria,[10] with the range of marginal bone loss seen in the first year reported to be around 0.7 mm.

Table 5 Immediate Loading Protocol

	No. of participants/ implants	Implant system	Implant surface	Attachment system	Observation period	Baseline measurement	Radiographic method (reference point)	Marginal bone loss	Success (SC) or survival (SU) rate
Marzola et al[46]	17 / 24	Brånemark	Roughened	Ball	1 y (prospective)	Implant placement	Paralleling technique (implant shoulder)	1 y: 0.7 mm	SU: 100%
Stricker et al[47]	10 / 20	ITI	Roughened	Bar	2 y (prospective)	Implant placement	Panoramics and periapicals (not specified)	1 y: 0.71 mm 2 y: 0.79 mm	SU: 100%

Discussion

This literature review was conducted to examine studies specifically related to marginal bone loss around two oral implants supporting mandibular overdentures. It is apparent that there have been several long-term studies involving conventional one- or two-stage loading protocols for mandibular two-implant overdentures. The implant success rates shown in those studies support a conventional loading protocol. Studies with early and immediate loading protocols showed comparable short-term findings of up to 100% success/survival rates. However, to recommend these protocols based on the short-term findings would be too premature.

There are several limitations to consider when analyzing the validity of marginal bone loss measurements and the success rates derived from them. Paralleling x-ray beams and the reproducibility of radiographs are necessary to minimize variability between examinations.[48–57] Studies that used panoramic radiographs[36,42] accepted the known distortion in the symphysial areas of the edentulous mandible. However, these authors concurrently attempted to justify the accuracy of panoramic radiographs and the validity of use due to the difficult anatomical situation in the anterior lingual sulcus in edentulous mandibles. Despite this reasoning, to compare the amount of marginal bone loss from studies using different radiographic approaches is questionable. The majority of studies specified reference points for measuring marginal bone levels, except for the ones that used panoramic radiographs or studies with baseline radiographs taken at implant placement. Without a reference point, the sequential radiographs must be taken with reproducibility to use the marginal bone level seen in the baseline radiographs as a reference point. However, any error in the radiographic method will affect the measurements of marginal bone loss seen at each examination. The gold standard radiographic method where filmholders can be mounted directly onto the implants[50,53,55,57] was used in several studies. However, some studies opted for the modified method,[40] using respective matrices on the filmholders rather than the direct and rigid attachment of the filmholders to the implants, since this method can become more difficult and painful for edentulous patients with a low mouth floor. Those studies employing standardized periapical radiographs should be regarded as more acceptable for comparing implant success rates. This review determined that the reported implant success rates could not be compared fairly because of the different radiographic methods used in each study.

Studies often used different time points to report the changes in marginal bone levels, with the majority failing to report marginal bone loss during the healing period. It is known that the majority of marginal bone loss occurs during the healing period prior to insertion of prostheses[58] and, as a result, the measurements taken prior to loading could not be compared fairly to measurements taken after loading. Some studies took baseline radiographs at loading, a few weeks after, or even 1 year after loading, assuming the baseline marginal bone level to be where an ideal surgical placement of the implant would be. This would lead to the observed changes in the marginal bone level during the healing period and any other additional period to be only estimates; the subsequent measurement would be affected since there was no confirmed baseline alveolar bone level for the measurement. In addition, with the lack of studies reporting changes in marginal bone levels during the healing period, it was inconclusive as to whether the amount of marginal bone loss prior to loading could be a prognostic determinant in implant dentistry. A recent study[59] demonstrated that implants with advanced bone loss (≥ 2.0 mm) prior to prosthesis insertion showed the largest progression rate of marginal bone loss during the first year of function, but a slow marginal bone loss thereafter. However, this result must be interpreted with caution since the large amount of initial resorption may not be applicable to severely resorbed residual ridges with mainly basal bone remaining. This brings up the issue of using only 1.0 mm of marginal bone loss during the first year as a criterion for implant success when this does not account for initial resorption status.

There was no consistency among studies in the reporting methods of determining marginal bone loss, ie, whether it was per implant site or per implant. Reporting the worst marginal bone loss measurement at a site[39] as a representation of the marginal bone loss for that particular implant could result in erring more on the side of failure than if measurements from two sites (mesial and distal) were averaged. This lack of consistency in the method of calculating annual marginal bone loss made it difficult to compare data from the different studies. In addition, some studies reported the marginal bone level at each examination only, and this led to difficulty in comparing their findings with those from studies that reported marginal bone loss, or the change in bone level between each time point.

It must also be acknowledged that the published studies included implants with different surfaces. With the introduction of roughened implant surfaces, especially with early and immediate loading protocols, these are additional variables needed to be considered. The influence of roughened-surface implants on marginal bone levels has not been established and therefore, care must be taken when comparing marginal bone loss data between studies using different loading protocols and different implant surfaces.

With the lack of uniformity in the limit of annual marginal bone loss to determine the success of implants, there are risks of misinterpreting data. Success rates from studies using a less strict marginal bone loss limit can result in higher success rates because some of the surviving implants would be classified as being successful. Studies that based their success rates on the criteria of Albrektsson et al[10] would be concerned only with the marginal bone loss that occurred subsequent to the first year of loading. However, studies using the success criteria by Albrektsson and Isidor[13] or Roos et al[14] would have to include the marginal bone loss during the first year of loading to determine the implant success rates. The former would introduce up to 1.5 mm more marginal bone loss to consider.

Owing to the wide methodologic variation among the included studies, it was difficult to compare data between different studies or to determine long-term marginal bone loss patterns. The limited data on long-term marginal bone loss around two implants supporting mandibular overdentures have shown high implant success/survival rates, with the marginal bone loss in the first year of loading, whether it be 1.0 mm or 1.5 mm, well below the limit suggested by different success criteria. This assumption, however, should be applied with caution since the validity of some of the methods of collecting marginal bone level data is questionable. It is difficult to recommend what the "normal" amount of cumulative marginal bone loss after the first year of loading should be with only a small number of studies reporting long-term data.

Conclusions

Short-term findings from each study showed that there are no detrimental effects on marginal bone levels using early or immediate loading protocols. Long-term findings required to validate the treatment outcome were limited in this review. Therefore, to recommend early or immediate loading protocols for two implants supporting mandibular overdentures may still be premature.

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Literature Abstract

Glycemic control and implant stabilization in type 2 diabetes mellitus

In this paper, the hypothesis that poor glycemic control is directly related to short-term implant stabilization impairment was tested. Fifty implants were placed in 35 individuals. One nondiabetic individual (1 implant) and 1 implant (of 2) from a person with diabetes were excluded due to rotational movement during the 4 months following implant placement. Additionally, 6 implants and two participants were excluded due to placement procedures inconsistent with the protocol. Data from 32 participants with 42 implants were analyzed in this study. Glycemic control was assessed by glycated hemoglobin (HbA1c) and implant stability by means of resonance frequency measurements (Implant Stability Quotient). These were taken in triplicate by means of the Osstell instrument. The stability level was recorded at baseline, 2, 4, 6, 8, 12, and 16 weeks following implant placement. The mean of the three measurements was used in the statistical analysis. Subjective clinical assessments were made regarding bone type according to a four-tiered scale, based on mineral densities during osteotomy: high density (type I), moderate density (type II), low density (type III), and very low density (type IV). Implant stability was significantly affected by the combination of HbA1c level and the time following implant placement (interaction of HbA1c and follow-up time, $P = .0094$). The maximum decrease in implant stability relative to baseline was significantly greater for the HbA1c 8.1% to 10.0% and HbA1c $\geq$ 10.1% groups compared with the nondiabetic (HbA1c $\leq$ 6.0%) and well-controlled diabetic groups (HbA1c 6.1% to 8.0%). In conclusion, the results of the current study justify the continued investigation of the effects of diabetes and glycemic control on bone metabolism, as well as the longer-term effects of glycemic control on implant integration, success, and complications for persons with type 2 diabetes.

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