Meta-Analysis of Correlations Between Marginal Bone Resorption and High Insertion Torque of Dental Implants

Haoyan Li, MS[1]/Yongqiang Liang, Dr Med Dent[2]/Qiang Zheng, BS[3]

Purpose: *To evaluate correlations between marginal bone resorption and high insertion torque value (> 50 Ncm) of dental implants and to assess the significance of immediate and early/conventional loading of implants under a certain range torque value.* ***Materials and Methods:*** *Specific inclusion and exclusion criteria were used to retrieve eligible articles from Ovid, PubMed, and EBSCO up to December 2013. Screening of eligible studies, quality assessment, and data extraction were conducted in duplicate. The results were expressed as random/fixed-effects models using weighted mean differences for continuous outcomes with 95% confidence intervals.* ***Results:*** *Initially, 154 articles were selected (11 from Ovid, 112 from PubMed, and 31 from EBSCO). After exclusion of duplicate articles and articles that did not meet the inclusion criteria, six clinical studies were selected. Assessment of P values revealed that correlations between marginal bone resorption and high insertion torque were not statistically significant and that there was no difference between immediately versus early/conventionally loaded implants under a certain range of torque.* ***Conclusion:*** *None of the meta-analyses revealed any statistically significant differences between high insertion torque and conventional insertion torque in terms of effects on marginal bone resorption.*
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Key words: *dental implant, dental implant loading, insertion torque, meta-analysis*

The clinical assessment of stability is often based on insertion torque measurements. Torques of 30 to 40 Ncm may ensure that sufficient stability has been achieved.[1] Traditionally, implants were preferably placed with a torque not exceeding an empirically set limit of 45 Ncm, because excessive strain on the surrounding bone resulted in tissue ischemia and microcirculation dysfunction, and in severe cases, necrosis of the osteocytes and bone resorption, resulting in a negative effect on osseointegration.[2,3] Therefore, it is necessary to consider an amount of torque that preserves physiology but ensures the stability of the implant.

Although the aforementioned concepts are widely accepted in the literature, high implant insertion torque (> 50 Ncm) is considered a prerequisite by some clinicians for clinical success in implant dentistry.[4–7] Higher insertion torque has been shown to significantly decrease the micromotion of implants and thus allow for immediate and early loading.[8,9] Stability is commonly related to insertion torque; therefore, high insertion torque is encouraged to improve the stability and osseointegration of implants.[9,10]

Primary stability refers to the stability of a screw immediately postinsertion; it results mainly from the greatest possible contact between the screw threads and bone[11] and can be improved through the use of a tapered, threaded implant in a slightly underprepared implant site.[10,12] This implant macrodesign has often been associated with elevated insertion torque,[12] and both underpreparation of the site and a tapered threaded implant design may help to increase primary implant stability.

The purpose of this article was to undertake a meta-analysis of methods to identify correlations between marginal bone resorption and high insertion torque of dental implants and to determine whether there is a difference in immediately and early/conventionally loaded implants within a certain range of torque values.

[1]Researcher, Department of Orthodontics, Medical School of Stomatology, Tangshan, North China University of Science and Technology, China.
[2]Professor, Department of Orthodontics, Medical School of Stomatology, Tangshan, North China University of Science and Technology, China.
[3]Assistant Professor, Department of Maxillofacial Surgery, Stomatology Hospital, Yangquan, Shanxi, China.

Correspondence to: Dr Yongqiang Liang, Department of Orthodontics, Medical School of Stomatology, Tangshan, North China University of Science and Technology, China. Email: lych810@foxmail.com

Table 1 Electronic Search Strategies Used

Database	Key words
Ovid MEDLINE (http://ovidsp.tx.ovid.com)	("high insertion torque" OR "high torque" OR "high insertion torque value") AND ("dental implant") ("high insertion torque" OR "high torque" OR "high insertion torque value") AND ("implant loading")
PubMed (http://www.ncbi.nlm.nih.gov)	("high insertion torque" OR "high torque" OR "high insertion torque value") AND ("dental implant") ("high insertion torque" OR "high torque" OR "high insertion torque value") AND ("implant loading")
EBSCO (http://web.b.ebscohost.com)	("high insertion torque" OR "high torque" OR "high insertion torque value") AND ("dental implant") ("high insertion torque" OR "high torque" OR "high insertion torque value") AND ("implant loading")

MATERIALS AND METHODS

Search Strategy

The search process was performed independently by two examiners under the guidance of a librarian. The Ovid, PubMed, and EBSCO databases were searched for articles published through December 2013 without language restriction. The search strategy included appropriate key words and variants and followed the syntax rules of each database. Unpublished and ongoing studies were not considered for inclusion. The main key words used were "dental implant," "high insertion torque," "high torque," "high insertion torque value," and "implant loading." The specific related terms used for each database are described in Table 1. The searches were complemented by screening the references of potentially included articles to find any additional articles that did not appear in the databases. The examiners identified the titles and reviewed the abstracts of potentially relevant studies independently. Full articles were obtained and reviewed before making a final decision. Articles appearing in more than one database search were considered only once.

The following inclusion and exclusion criteria were used to identify eligible studies. All studies had to include at least 10 implants. The maximum insertion torque value (conventional value or torque value > 50 Ncm) had to be measured during implant insertion. The minimum mean follow-up period was 12 months. Only randomized controlled trials (RCTs) or controlled clinical trials (CCTs) were considered for inclusion in the meta-analysis. Animal trials, case reports, and in vitro experiments were excluded. Any study that evaluated insertion torque but did not verify its significance was eliminated from consideration. In addition, any articles with significant flaws in the study design or lack of statistical analysis were excluded from this review.

Data Extraction and Assessment

The titles and abstracts of the articles were screened by two authors independently for possible inclusion in this review. After a consensus was reached, the full texts of all potentially relevant studies were obtained. All studies that met the inclusion criteria underwent assessment for validity and data extraction. Data were extracted by two review authors independently. Any disagreement on candidate articles was resolved by discussion. All authors were contacted for clarification or to supply missing information. According to this classification of studies and important reference indexes, the significance of correlations between parameters and high insertion torque values was determined.

Assessment of quality and potential bias of the articles were performed by two authors using a checklist. Information left unreported or unclear led to an "unclear" classification. Further quality assessment was carried out to assess sample size calculations, definitions of exclusion/inclusion criteria, bias caused by subjective factors (eg, problems with measurement inaccuracy, calibration of torque wrenches, surgical experience) and to determine the comparability of the control and experimental groups in all included studies.

Statistical Analysis

Statistical analyses were performed with Review Manager 5.2 (Cochrane Collaboration). Meta-analysis was performed to provide a full and comprehensive summary of related studies.[13] The correlation coefficient (r) was combined using the fixed and random effect models. Heterogeneity of the studies was tested by performing the homogeneity test. Significant heterogeneity was indicated by $P < .1$ because of the moderate insensitivity of the Q statistic.[14] The value of I^2 ranged from 0 to 100, with larger values (≥ 75) suggesting high heterogeneity.[15] In the event homogeneity was found between studies, the outcome of a fixed-effect model was used; if heterogeneity was found, it was appropriate to use the result of a random-effect model.[16]

RESULTS

The electronic searches retrieved 11 articles from Ovid, 112 articles from PubMed, and 31 articles from EBSCO. No relevant additional articles were found by hand search. Some other databases were discontinued because of poor yield. After all of the duplicate articles were removed, 11 articles were selected by title and abstract reading according to inclusion/exclusion criteria. After the complete texts were read, 5 articles were excluded. Finally, a total of 6 articles fulfilled the inclusion criteria. Six articles were included in the review, and the data extracted from them were tabulated (Tables 2 and 3). Two of the selected articles were conducted by the same group, and because there may have been some overlapping patients, the data were adopted only once.

Among the six included articles, *P* values for comparative evaluation of high insertion torque and the result of marginal bone resorption were provided in two studies (Grandi et al[17] and Khayat et al[12]). Correlations between insertion torque and marginal bone resorption are presented in Table 2.

With respect to marginal bone resorption and the time of loading, the meta-analysis of two trials (Grandi et al[17] and Khayat et al[12]) found no significant difference, with weighted mean difference (WMD) random effects of –0.09 (95% confidence interval [CI], –0.43 to 0.24) (Table 4).

With respect to marginal bone resorption during the 12 months after implant placement, the meta-analysis of two trials (Grandi et al[17] and Khayat et al[12]) found no significant difference, with WMD fixed effects of –0.03 (95% CI, –0.12 to 0.05). There was no evident heterogeneity, although only two trials were included (Tables 2 and 5). No statistically significant differences in marginal bone resorption were observed; however, the number of trials and patients included may have been insufficient to draw definitive conclusions.

Meloni et al[18] and Achilli et al[19] compared immediate loading with early/delayed loading after 12 months when conventional insertion torque was used. The meta-analysis of them found no significant difference, with WMD fixed effects of –0.03 (95% CI, –0.10 to 0.04). There was no evident heterogeneity, although only two trials were included (Tables 3 and 6).

DISCUSSION

In the present meta-analysis, most of the included studies focused on orthodontic mini-implants within variable intervals of torque and the effects on different bone quality. The current meta-analysis investigated the correlation between the stated maximum insertion torque and marginal bone resorption. The question of whether implants can be placed with high insertion torque has relevant clinical implications, since high insertion torque may reduce the rates of implant failure.

Grandi et al[17] used tapered self-tapping implants (JDEvolution, JDental-Care) with dual threads and concluded that crestal bone resorption of implants placed with high insertion torque (50 to 80 Ncm) was similar to that of implants placed with conventional insertion torque (30 to 45 Ncm). All of the implants were inserted successfully with a seating torque ranging between 50 and 80 Ncm. Khayat et al[12] showed that high insertion torque (up to 176 Ncm) with Tapered Screw-Vent implants (Zimmer Dental) neither prevented osseointegration nor increased marginal bone resorption around tapered multithreaded dental implants. Marginal bone resorption was similar between the control group (30 to 50 Ncm) and the experimental group (70 to 176 Ncm) at the time of early loading and 1 year later.

Meloni et al[18] compared the outcome of immediate nonocclusal loading with that of delayed implant loading in the bilateral replacement of single mandibular molars in a randomized, controlled, split-mouth trial. Forty patients were included in the immediately loaded group and 40 in the conventionally loaded group. There were no failures at 1 year. The present data seem to confirm the hypothesis that the clinical outcome of immediate versus delayed loading of implants in single mandibular molar sites is comparable at torque values of 35 to 45 Ncm. Achilli et al[19] used 120 tapered implants in premolar and molar areas of the mandible and maxilla with insertion torque between 35 and 45 Ncm. A 100% cumulative success rate for the implants was achieved. The study indicated that immediate and early function were both predictable approaches in the posterior regions of both arches. Ottoni et al[10] noted that the risk of failure can be decreased by 20% per 9.8 Ncm of additional insertion torque and asserted that immediate loading of single implants should be considered only if the insertion torque is above 32 Ncm. However, it has been noted that, for fresh extraction sites, the insertion torque should be greater than 35 Ncm.[20,21] In another study, Grandi et al[22] compared survival and peri-implant bone levels after immediate and early loading in partially edentulous patients up to 12 months after implant placement. Insertion torque values varied from 30 to 100 Ncm in the early loading group and from 55 to 95 Ncm in the immediate loading group. The data indicated that, if adequate primary stability is achieved, immediate loading of dental implants can provide similar success rates, survival rates, and peri-implant bone resorption as early loading. In another study, Grandi et al[23] observed that immediately loaded single postextraction implants placed in the anterior maxilla with high insertion torque (50 to 80 Ncm) showed favorable outcomes. There was no statistically significant difference in the posterior arches between immediate and early/delayed loading strategies, regardless of whether conventional or high insertion torque was used.

Table 2 Selected Articles on High Insertion Torque Value

Study	Type	Implant dimensions	Sample	Sites	Implant and manufacturer	No. of implants placed
Grandi (2013)[17]	Prospective	3.7 × 8 mm	n = 102 Cont: 15 F, 11 M, mean age 55.3 y Exp: 49 F, 27 M, mean age: 51.8 y	Partially edentulous arch	Tapered self-tapping (JDEvolution, JDental-Care)	156
Khayat et al (2013)[12]	Prospective	4.5 × 10, 13, or 16 mm	n = 48 23F, 15 M Mean age: 63 y	Unclear	Sandblasted and acid-etched, Tapered Screw-Vent (Zimmer Dental)	66
Grandi et al (2012)[23]	RCT	4.3 or 5 × 13 or 15 mm	n = 36 20 F, 16 M Mean age: 37.4 y	Anterior Maxilla	Tapered, self-tapping/self condensing (JDEvolution, JDental-Care)	36

Cont = control group; Exp = experimental group; ITV = insertion torque value.

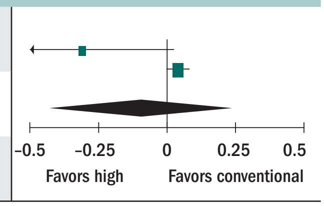
Table 3 Selected Articles on Immediate Loading Versus Early/Delayed Loading Within a Range of Torque Values

Study	Type	Implant dimensions	Sample	Sites	Implant and manufacturer	No. of implants placed
Meloni et al (2012)[18]	RCT	4.3 or 5 × 8 or 10 mm	n = 20 12 F, 8 M Mean age: 46 y (range, 28–70)	Single mandibular molars	Nobel Replace Tapered Groovy (Nobel Biocare)	80
Achilli et al (2007)[19]	Prospective	Lengths: 10, 13, 16 mm	n = 51 28 F, 23 M Mean age 52.5 y (31–80)	Premolar and molar	Replace Select TiUnite Tapered (Nobel Biocare)	110
Grandi et al (2012)[22]	RCT	4.3 or 5 × 10, 11.5, or 13 mm	n = 80 49 F, 31 M Mean age: Cont: 55.8 y (43–60), Exp: 51.8 y (39–60)	Premolar and molar	Tapered self-tapping (JDEvolution, JDental-Care)	161

Cont = control group; Exp = experimental group; ITV = insertion torque value.

Table 4 Forest Plots for the Effect on Marginal Bone Resorption of High Insertion Torque Value (Experimental) Versus Conventional Insertion Torque Value (Control), Measured at the Time of Early Loading

	High torque			Conventional torque			Mean difference		Mean difference
Study or subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV, Random, 95% CI
Khayat et al (2013)[12]	0.72	0.56	42	1.03	0.44	9	38.3%	−0.31 [−0.64, 0.02]	
Grandi et al[17]	0.33	0.1	114	0.29	0.12	42	61.7%	0.04 [−0.00, 0.08]	
Total (95% CI)			156			51	100.0%	−0.09 [−0.43, 0.24]	



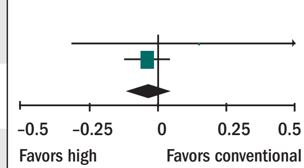
Heterogeneity: $Tau^2 = 0.05$; $Chi^2 = 4.17$, df = 1 (P = .04); $I^2 = 76\%$
Test for overall effect: Z = 0.55 (P = .58)
IV = inverse variance.

Mean ITV (N)	Time of loading	Type of bone evaluated	Follow-up	Survival rate (%) (12–37 mo)	Early failure	Association between high ITV and result
Cont: 37.4 ± 8.2 Exp: 74.8 ± 7.9	2 mo (early)	Sufficient bone volume	6, 12 mo	100	0	Mean bone resorption after 6 mo: Exp 0.33 ± 0.1 mm, Cont 0.29 ± 0.12 mm (*P* > .05) Mean bone resorption after 12 mo: Exp 0.41 ± 0.18 mm, Cont 0.45 ± 0.25 mm (*P* > .05)
Cont: 37.1 Exp: 110.6	2 mo (early)	Sufficient bone volume	12 mo	100	0	Mean bone marginal resorption at time of loading: Exp 0.72 ± 0.56 mm, Cont 1.03 ± 0.44 mm (*P* > .05) Mean bone resorption after 1 y: Exp 1.24 ± 0.75 mm, Cont 1.09 ± 0.62 mm (*P* > .05)
70.55 (range 50–80)	Immediate	Most D2; no D4	10 d and 3, 6, 12 mo	97.2% (12 mo)	1	Bone resorption between 0, 6, and 12 mo was statistically significant (*P* < .0001)

Mean ITV (N)	Time of loading	Type of bone evaluated	Follow-up	Survival rate (%) (12 mo)	Early failures	Association between high ITV and result
35–45	Immediate and delayed	Provisional acrylic resin crowns and zirconia-ceramic crowns	6, 12 mo	100	0	Mean bone resorption after 1 y: Exp 0.83 ± 0.16 mm, Cont 0.86 ± 0.16 mm (*P* > .05)
35–45	Immediate and early	Unclear	12 mo	100	0	Mean bone resorption after 1 y: Exp 1.24 ± 0.88 mm, Cont 1.09 ± 1.01 mm (*P* > .05)
30–100	Immediate and early	Unclear	2 wk and 2, 6, and 12 mo	100	0	Mean bone resorption after 1 y: Exp 0.421 ± 0.009 mm, Cont 0.467 ± 0.012 mm (*P* > .05)

Table 5 Forest Plots for the Effect on Marginal Bone Resorption of High Insertion Torque Values (Experimental Group) Versus Conventional Insertion Torque Values (Control Group) After 12 Months

	High torque			Conventional torque			Mean difference		Mean difference
Study or subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI	IV, Fixed, 95% CI
Khayat et al (2013)[12]	1.24	0.75	42	1.09	0.62	9	3.1%	0.15 [–0.31, 0.61]	
Grandi et al[17]	0.41	0.18	114	0.45	0.25	42	96.9%	–0.04 [–0.12, 0.04]	
Total (95% CI)			156			51	100.0%	–0.03 [–0.12, 0.05]	

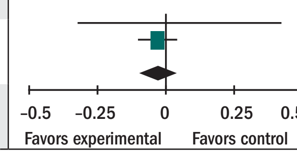


Heterogeneity: $Chi^2 = 0.62$, df = 1 (*P* = .43); $I^2 = 0\%$
Test for overall effect: Z = 0.82 (*P* = .41)

The evidence to support the relationship between high insertion torque (> 50 Ncm) and marginal bone resorption is still weak if the quality assessment and amount of bias in the included studies are taken into account.[24] The methodologic quality of future studies needs to be improved to produce stronger evidence, preferably with the use of multivariate analysis.

Table 6 Forest Plots for the Effect on Marginal Bone Resorption of Immediate (Experimental) Loading Versus Early/Delayed (Control) Loading of Same Conventional Torque Value After 12 Months

	Immediate loading			Early/delayed loading			Mean difference		Mean difference
Study or subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI	IV, Fixed, 95% CI
Achilli et al (2007)[19]	1.24	0.88	68	1.19	1.01	42	3.5%	0.05 [−0.32, 0.42]	
Meloni et al (2012)[18]	0.83	0.16	40	0.86	0.16	40	96.5%	−0.03 [−0.10, 0.04]	
Total (95% CI)			108			82	100.0%	−0.03 [−0.10, 0.04]	



Heterogeneity: Chi^2 = 0.17, df = 1 (P = .68); I^2 = 0%
Test for overall effect: Z = 0.77 (P = .44)

CONCLUSIONS

Marginal bone resorption around implants placed with high insertion torque (> 50 Ncm) is not statistically significantly different from that seen around implants placed with conventional insertion torque (35 to 45 Ncm). The cumulative success rate of implants placed with high insertion torque was not statistically significantly different from that of implants placed with conventional insertion torque. Well and simply designed randomized controlled studies and controlled clinical trials are needed to understand the predictability of the protocols for high insertion torque when used with different loading protocols. Although not all clinicians may be able to achieve optimal results with high insertion torque or immediate loading, high insertion torque seems to be one of the prerequisites for successful implant therapy.

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