The Effects of High Insertion Torque Versus Low Insertion Torque on Marginal Bone Resorption and Implant Failure Rates: A Systematic Review With Meta-Analyses

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Objectives: *The aim was to analyze the data about the effects on marginal bone resorption and implant failure rates between implants inserted with high or low insertion torque values.*

Materials and Methods: *A systematic literature search until July 2015 was conducted. Data were summarized qualitatively in descriptive tables and quantitatively by performing random effects meta-analyses of effect sizes (ESs) for bone resorption and bone-to-implant contact (BIC) and relative risks (RRs) for implant failures. Risk of bias assessments were performed using the Cochrane tool for human studies and the SYRCLE's tool for animal studies.*

Results: *Four studies in humans and 6 quasirandomized animal studies were included. A total of 591 implants were evaluated qualitatively: 348 installed with high insertion torque (>25 Ncm, up to 176 Ncm) and 243 implants inserted with low torque values (<30–35 Ncm). No significant differences were detected for bone resorption (ES, 0.13; 95% confidence interval [CI], −0.12 to 0.38 in human studies; ES predictive interval from 35.03 to 34.50 in animal studies), implant failure (RR, 0.39; 95% CI, 0.01–20.77 in human studies; RR, 2.05; 95% CI, 0.19–21.71 in animal studies), or BIC (ES predictive interval from −3.84 to 5.13 in animal studies).*

Conclusion: *The current review indicated that there is no significant difference in marginal bone resorption and implant failure rate between implants inserted with high or low insertion torque values. (Implant Dent 2016;25:1–9)*

Key Words: peri-implant bone remodeling, osseointegration, implant primary stability, torque review, titanium implants

The main goal for the oral implantologist, after dental implant surgical procedures, is represented by reaching a sufficient primary stability that ensures high success rates. It is well known that titanium implant osseointegration processes started with an initial rigid implant fixation into the host bone; this initial stability is a mechanical one, and it is mainly related to implant torque insertion values, bone density, and implant features such as macro- and microgeometries.

A correlation between implant mechanical stability, insertion torque, and bone density was demonstrated in a previous *in vitro* evaluation performed by Trisi et al[1] They inserted implants using 5 insertion torque peaks in 3 different bone densities (soft, medium, and hard) and then measured the implant micromobility during the application of lateral forces. They demonstrated that high implant micromobilty was typical in poor bone quality and it was related to low insertion torque value.

The importance of considering the association of bone quality, insertion torque values, and implant stability was also underlined by Herekar et al[2] who introduced the BITS score (bone,

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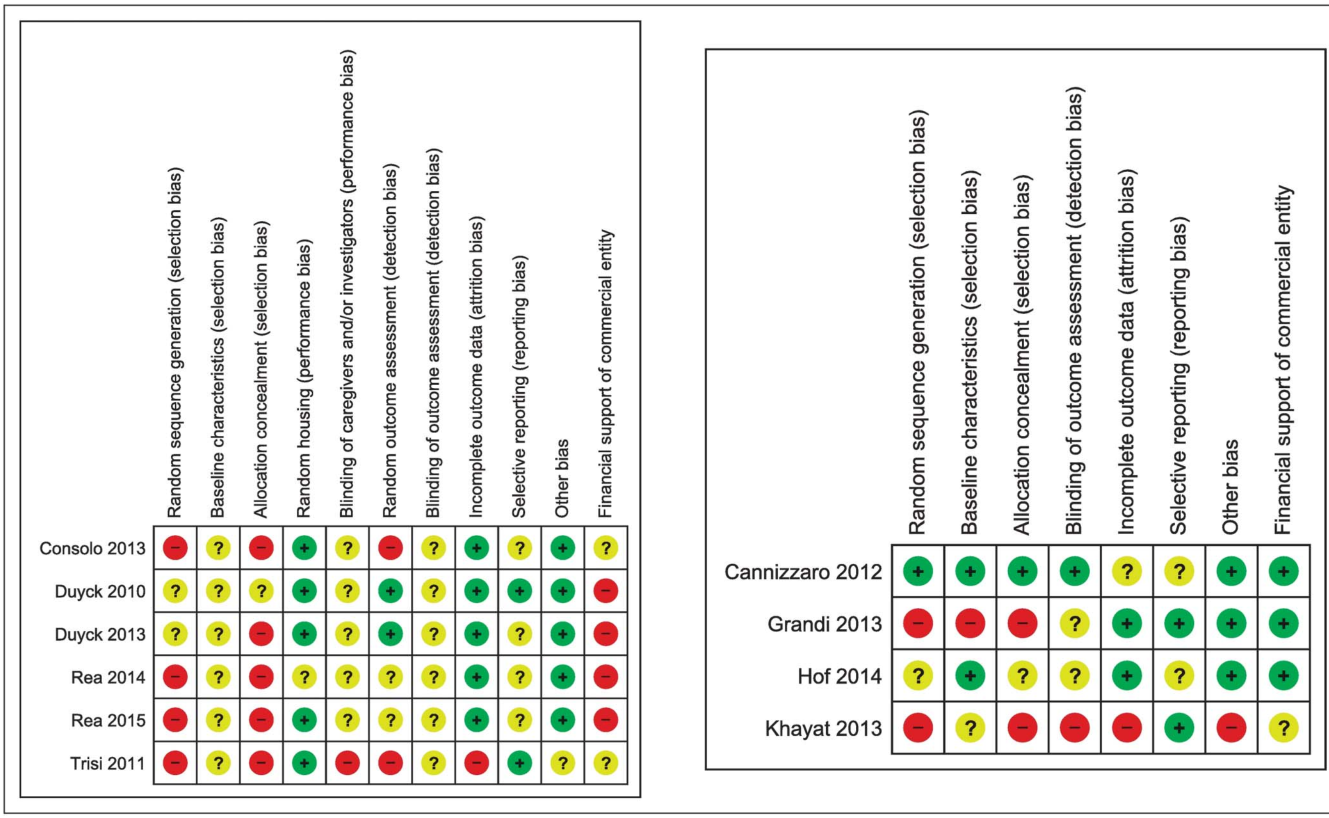

Fig. 1. Left side, risk of bias summary in animal studies. Right side, risk of bias summary in human studies.

insertion torque, implant stability) to control implant healing and perform possible alterations in the treatment plan as a delayed load or progressive load protocols.

The need of an adequate primary stability, guaranteed by a sufficient insertion torque value, increased his importance especially in 1-stage implants or in immediate loading protocols. Today, implant immediate loading protocols are widespread because the patients' main request is to have fixed implant supported rehabilitation with reduced pain and discomfort. New implant design with larger threads have been developed during the past years in order to increase the primary stability (and insertion torque), and they are especially made for the immediate loading or poor bone density. Surgical techniques that allow better implant stability and higher insertion torque values, as undersized implant sites or osteocondensation, have been developed and strongly suggested in case of poor bone quality.[3,4]

If no doubts exist about the correlation between insertion torque peaks and implant stability, it is not clarified what is the proper insertion torque value and if a threshold level of insertion torque does exist that could, eventually, induce bone resorption.

Some authors demonstrated that implants inserted with high torque values could be immediately loaded, and so the insertion torque is in no way harmful for hard and soft tissue.[5–10] Other authors reported that high insertion torque value is one of the main causes of marginal bone resorption[11] or, however, not necessary.[12–15]

The aim of this article is to review the recent international literature about low and high implant insertion torque investigating their effects on marginal bone loss and implant survival rate.

Materials and Methods

A systematic literature search using the terms "insertion torque," "high torque implants," and "low torque implants" and limited by "English" in Medical Literature Analysis and Retrieval System Online, Embase, Scopus, and the Cochrane Library databases was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.

The objective of the search was to find all the published papers until July 31, 2015, that compared or evaluated the effect of different implants' torque insertion values on marginal bone resorption or implant failure rates. Randomized and controlled *in vivo* studies that compared the outcomes in bone resorption and implant failure rates of implants inserted with low insertion torque versus high insertion torque were included in the review. Case reports or technical reports without control group were excluded. *In vitro* studies that evaluated the implant stability using different torque values were also excluded because they are static and do not assess the effects on bone resorption and implant failure rate.

The study presented by Norton,[12] in which he inserted 68 implants with

Table 1. Group 2: Studies Included in the Review Theorizing That High Insertion Torque Does Not Cause Marginal Bone Resorption or That High Torque Could Be Useful in Immediate Loading Protocols or in Poor Bone Density Situations

Authors	Study Type	Implant Numbers	Torque in Test Group	Torque in Control Group	Follow-Up	Results
Trisi et al[22]	Controlled randomized: *in vivo* (sheep)	40	(20 implants), mean 110 Ncm	(20 implants), mean 10 Ncm	1, 2, 3, 4, and 6 wk	Implants from the test group showed significantly higher bone apposition than implants from the control group at all examined healing times. Similarly, removal torque was consistently higher for the test group when compared with the control group.
Cannizzaro et al[6]	Controlled randomized: *in vivo* (humans)	100	(50 implants), >80 Ncm	(50 implants), range 25–35 Ncm	6 mo	Seven implant failures in low-torque group immediately loaded. It is preferable to insert single implants with a high insertion torque (>80 Ncm), to minimize early implant failures, when loading them immediately.
Duyck et al[21]	Controlled randomized: *in vivo* (rabbits)	20	(10 implants), >50 Ncm	(10 implants), <10 Ncm	2–4 wk	More %BIC in test group implants at early healing time. No negative impact of high insertion torque.
Khayat et al[7]	Prospective: *in vivo* (humans)	51	(42 implants), >70 Ncm (mean 110.6 Ncm; range 70.8–176 Ncm)	(9 implants), <50 Ncm (mean 37.1 Ncm; range 30–50 Ncm)	1 y	No differences in marginal bone resorption.
Grandi et al[9]	Multicenter controlled randomized: *in vivo* (humans)	156	(114 implants), range 50–80 Ncm (mean 74.8 Ncm)	(42 implants), range 30–45 (mean 37.4 Ncm)	1 y	There were no significant differences between the 2 groups in crestal bone loss.
Consolo et al[8]	Controlled randomized: *in vivo* (sheep)	12	(6 implants), >25 Ncm (mean 105.6 Ncm)	(6 implants), <25 Ncm (mean 24 Ncm)	8–12 wk	No significant differences in histological evaluation, resonance frequency analysis, removal torque.
Hof et al[10]	Controlled randomized: *in vivo* (humans)	84	(42 implants), >50 Ncm	(42 implants), <20 Ncm	1 y	No clinically significant differences in marginal bone resorption after 1 y could be observed.
Total		463	284	179		

Table 2. Group 1: Studies Included in the Review Theorizing That High Insertion Torque Could Cause Bone Resorption or, However, It Is Not Necessary

Authors	Study Type	Implant Numbers	Torque in Test Group	Torque in Control Group	Follow-Up, mo	Results
Duyck et al[11]	Controlled randomized: *in vivo* (minipigs)	80	(40 implants), experimental implants with high torque	(40 implants), low torque	1, 2, and 3	The experimental implant design caused significantly more peri-implant bone loss compared with the control implant.
Rea et al[14]	Controlled randomized: *in vivo* (dogs)	24	(12 implants), >70 Ncm	(12 implants), 30 Ncm	4	Higher BIC% was found at the lower compared with the higher final insertion torque. High insertion torque is not necessary.
Rea et al[15]	Controlled randomized: *in vivo* (dogs)	24	(12 implants), >70 Ncm	(12 implants), 0 and 30 Ncm	4	Similar amounts of osseointegration were obtained irrespective of the insertion torque applied.
Total		128	64	64		

low torque (<25 Ncm) and immediately subjected them to load, concluded that high torque insertion values are not necessary. The study itself was not included in the present review because it does not have a control group and higher torque levels were not tested. Conventional loading or immediate loading were both included. The follow-up duration was not among inclusion or exclusion criteria because the aim of the review was to establish if there are differences in bone resorption or implant failure between different torque values, after the same healing time. Different follow-up times are useful to better understand if these differences really exist. Articles were selected by 2 different reviewers who based their choice on inclusion and exclusion criteria.

We used the Cochrane Risk of Bias (RoB) Tool to assess the RoB of the individual studies in humans, and the recently published SYRCLE's tool (SYstematic Review Centre for Laboratory animal Experimentation) to assess the RoB in animal studies.[16] An experienced systematic reviewer-epidemiologist (A.W.S.R.) verified all RoB assessments of the first reviewer who had ample content expertise (B.S.). We refer to the Cochrane Handbook for Systematic Reviews of Interventions[17] and Hooijmans et al[16] for the general RoB definitions applied. We did not judge blinding of the treating dentists or patients in the human studies, because such blinding is not feasible. We summarized study characteristics and the outcome data qualitatively in the tables.

Whenever possible, we used standard inverse variance random effects meta-analysis to combine outcome data across all studies at the end of trial, stratifying by type of study (human versus animal). Binary outcomes were expressed as risk ratios (RR) where we excluded comparisons with 0 events in both groups in the meta-analyses.[18] Continuous outcomes were expressed as effect sizes (ESs), where 0.2 is typically interpreted to represent a small effect, 0.5 a moderate effect, and 0.8 a large effect.[19]

We visually inspected forest plots for the presence of heterogeneity and calculated the I^2 statistic and the corresponding Chi-square test to assist the interpretation of between-study heterogeneity. I^2 describes the percentage of variation across studies attributable to heterogeneity rather than chance, with values of 25%, 50%, and 75% typically being interpreted as low, moderate, and high between-study heterogeneity, respectively.

In the absence of high heterogeneity, we depicted summary estimates with confidence intervals (CIs). In the presence of high heterogeneity, we only depicted predictive intervals to summarize the data. The prediction interval approximates the 95% CI for an estimate of an outcome of a future trial, based on the extent of between-study heterogeneity and standard errors of the studies.[20] The broader the interval, the less sure we are about the magnitude of the estimate of an outcome. We did not perform any subgroup or funnel plot analyses to explore the effects of patient, animal, implant, or design characteristics on the estimates of the outcomes, because of the low number of studies identified. All *P* values are 2-sided.

We used STATA, release 13 (StataCorp, College Station, TX) to analyze the data, and Review Manager 5.3 (Available from http://tech.cochrane.org/revman) to generate RoB figures.

RESULTS

The search identified 1.146 citations of which 1131 were excluded on the basis of title and abstract screening. Of the 15 full text articles obtained, 10 reports of controlled studies, including 1 true randomized and 7 quasirandomized *in vivo* studies were evaluated: 4 studies in humans and 6 studies in animals.

A split mouth quasirandomized design was used in 2 human studies (Cannizzaro et al[6]; Hof et al[10]); the remainder concerned nonrandomized studies (Grandi et al[9]; Khayat et al[7]).

With regard to the animal studies, 5 of 6 used a split mouth quasirandomized

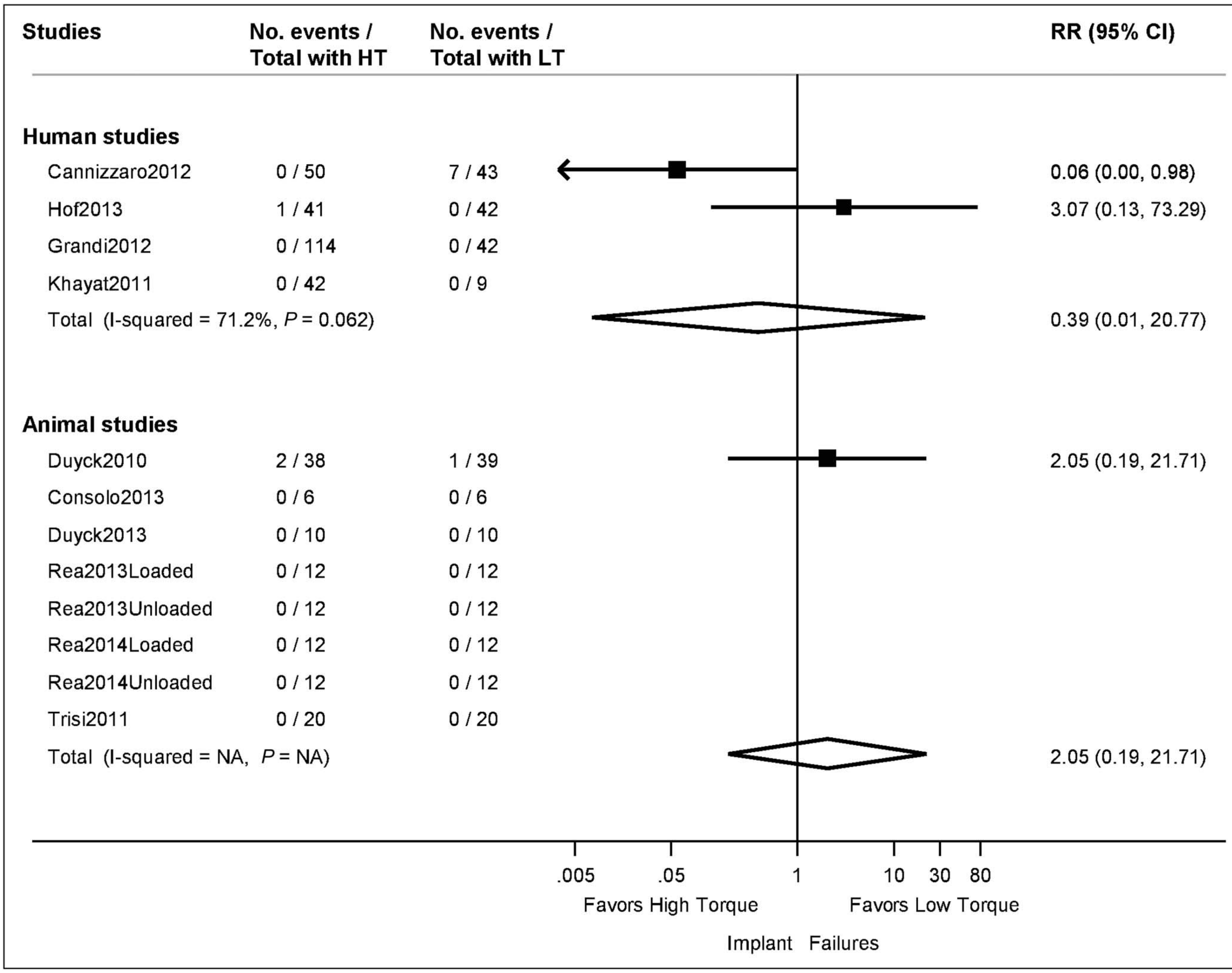

Fig. 2. Insertion torque value effects on implant failure rate. No significant differences were detected between high- and low-insertion torque groups in implant failure rate. One human study (Cannizzaro et al 2012) reported higher implant failure rate in low insertion torque implant immediately loaded.

design; the study by Duyck et al[21] was performed in the tibia of rabbits (Fig. 1).

There was no agreement, in the published articles, on the cutoff to define low insertion torque and high insertion torque: some studies defined low insertion torque below 25 Ncm and others below 35 Ncm (Tables 1 and 2). A total of 591 implants were evaluated: 348 installed with high insertion torque (>25 Ncm, up to 176 Ncm) and 243 implants inserted with low torque values (<30 Ncm).

Only Cannizzaro et al[6] reported adequate random sequence generation and concealment of allocation. In the Hof et al[10] study, the description concerning sequence generation and concealment was lacking. Studies by Grandi et al[9] and Khayat et al[7] are nonrandomized ones at high risk of selection bias. In the Grandi et al[9] study there was some evidence that baseline characteristics between the low- and high-torque groups were dissimilar. Only Cannizzaro et al[6] reported blinding of outcome assessors.

Two of 4 human studies were judged to be free of attrition bias, with 83 of 84 treated implants available for the analyses in Hof et al' study,[10] and 156 implants of 156 treated sites available for analyses in Grandi et al's[9] study. We refer to Figure 1 for additional RoB assessments.

As for the analysis of animal studies, none of the animal studies reported a random sequence generation or concealment of allocation that we judged to be at low RoB. Comparability of baseline characteristics at baseline was unclear in all studies, typically because of the lack of reporting on bone quality and quantity. As none of the studies reported adequate concealment of allocation, we are unsure if prognostic characteristics/confounders are distributed equally between the implant positions and healing times. None of the animal studies reported blinding of caregivers, investigators, or outcome assessors, which may have put the studies at risk of performance and detection bias.

Only 1 study was judged to be at high risk of attrition bias because of incomplete outcome data.[8] Trisi et al[22] analyzed 30 of 40 (75%) inserted implants for bone-to-implant contact (BIC) analyses, and 10 implants were reserved for the removal torque test analysis. We acknowledge that the selection process of the 6 implants per sheep was not described, putting the study at high RoB, as the 2 not-analyzed implants per sheep may have been dissimilar from the analyzed implants. We graded this risk at the item "random outcome assessment," but not again at the item on attrition bias, to avoid duplicate downgrading for the same reason. The remaining 4 studies analyzed all implants according to the intent-to-treat principle.

We refer to Figure 1 for the RoB assessment of all other RoB items. Detailed explanations are available from the corresponding author.

On the basis of torque effects on peri-implant bone, the analyzed human studies could be divided into 2 groups: group 1 theorizing that high insertion torque could cause bone resorption or, however, is not necessary and group 2 concluding that high insertion torque does not cause bone resorption and is useful in case of immediate loading or poor bone quality (Tables 1 and 2). All 4 human studies (247 implants with a high torque and 136 with a low torque) reported on implant failures; 2 of these studies contributed to the meta-analyses. No statistical differences were found in implant failure rate between high torque versus low torque insertion values (Fig. 2). None of the human studies reported data on % BIC.

On a study level, the trialists reported the absence of statistical differences in bone marginal resorption between high and low implant insertion torque in all 4 studies Meta-analyses of the analyzable data across 3 studies did not result in statistically significant differences either (ES, 0.13; 95% CI, –0.12 to 0.38; I^2, 0.0%) (Fig. 3).

In animal evaluations, similar to the human studies, when evaluating bone resorption at a study level in a qualitative manner, the absence of statistical differences in bone marginal resorption between high and low implant insertion torque was noted in 9 of the 10 studies analyzed. Only 1 study[11] reported that 40 implants installed with high insertion torque showed significantly more bone resorption but the implant macrodesign used in the comparison between test and control group was different.

Quantitative data were available from 3 comparisons, but the observed between-study heterogeneity was too large ($I^2 = 89.4$) so that we refrained from depicting summary estimates. The predictive interval is depicted for illustrative purposes, to indicate how unsure we are about the magnitude and direction of the summary estimate.

All 6 animal studies reported on implant failures, and 5 of these studies reported the absence of such failures in both the high- and low-torques sites, so that meta-analyses were not performed. Duyck et al[11] did not detect

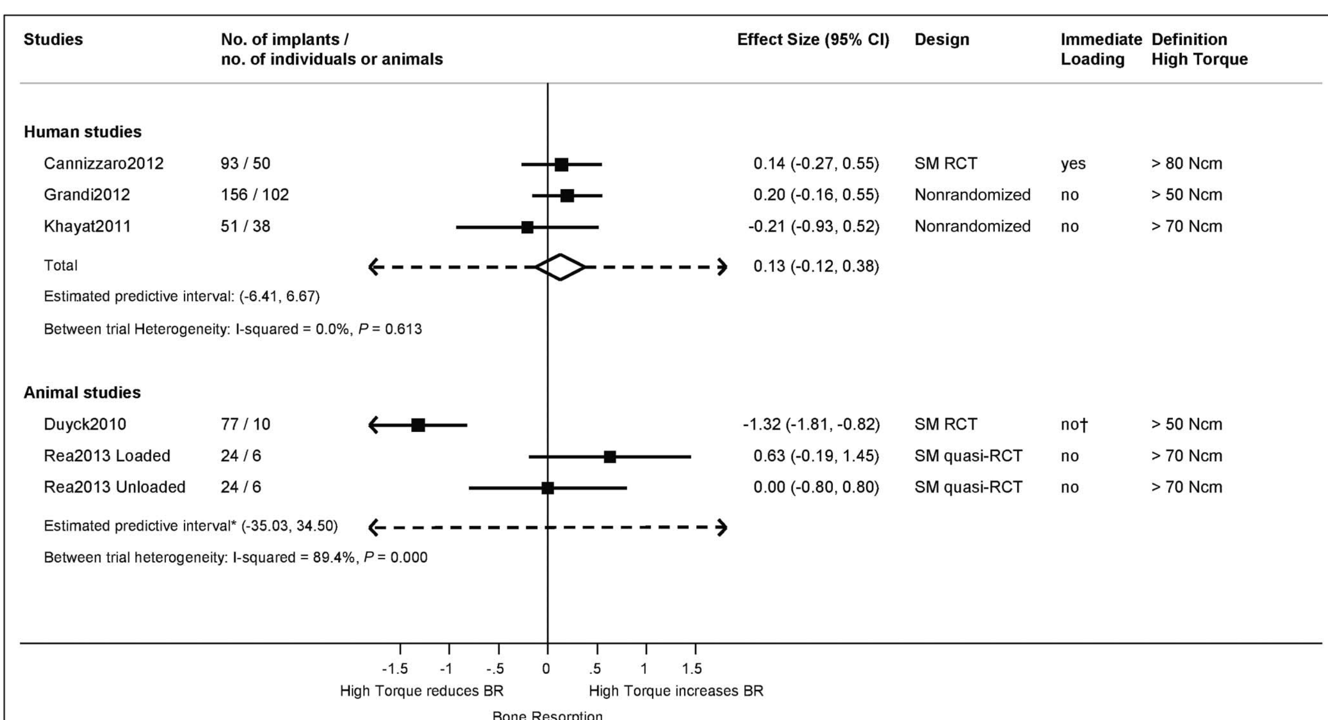

Fig. 3. Insertion torque values' effects on peri-implant bone resorption. No significant differences were detected between high- and low-insertion torque groups in peri-implant bone resorption. Dashed lines, truncated predictive intervals (see methods) rectangles with solid study lines, study estimates with confidence intervals; diamond, estimated pooled effect size across studies with its confidence interval. *Pooled estimate not depicted in light of the large observed between-study heterogeneity. †Immediately unloaded. SM indicates split mouth; RCT, randomized controlled trial.

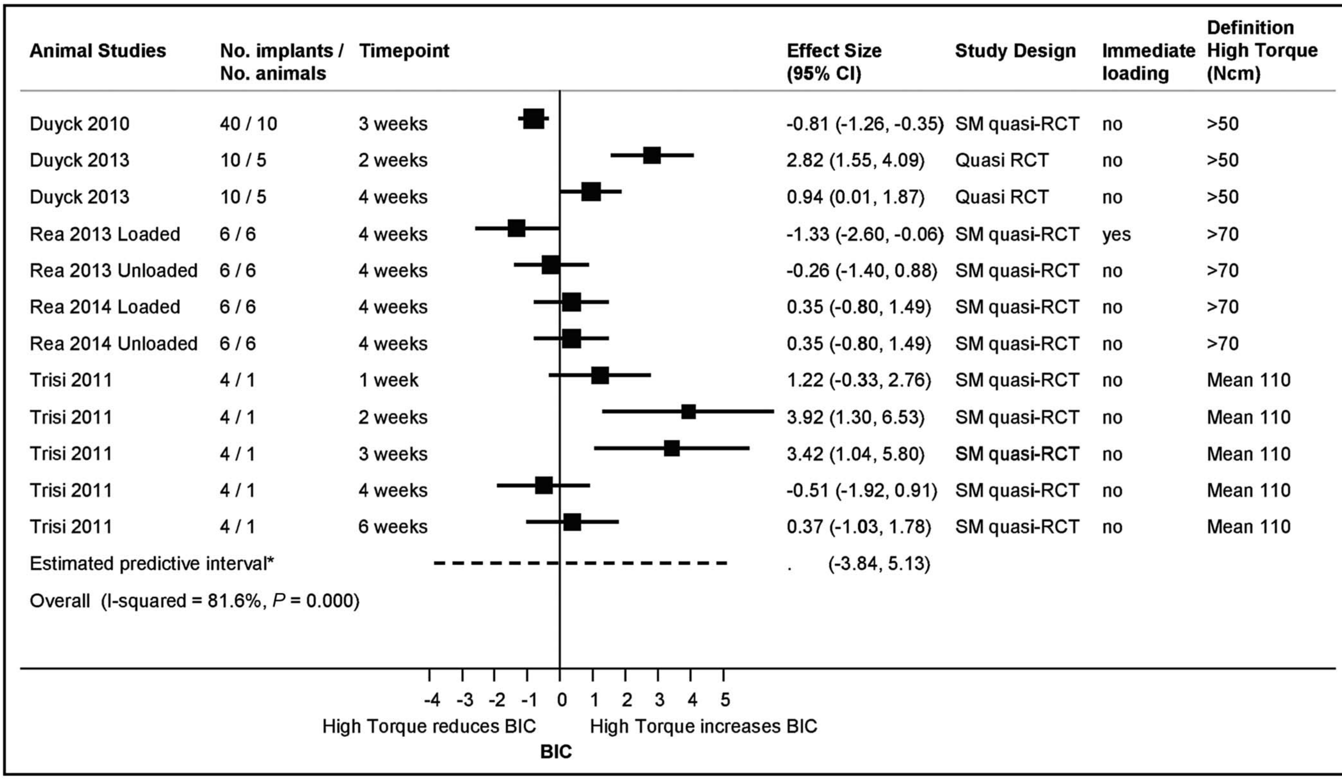

Fig. 4. Insertion torque values' influence on %BIC in animal studies. High insertion torque values caused higher %BIC values than low insertion torque during the first weeks of healing (primary stability). Once the secondary stability is achieved %BIC values are almost the same between implants inserted with high or low insertion torque. Dashed line, prediction intervals; rectangles, study estimates; solid study lines, confidence intervals. *Pooled estimate not depicted in light of the large observed between-study heterogeneity; the predictive interval is derived from a univariable meta-regression model with the observed standard errors as explanatory variables from each comparison. We refrained from a hierarchical model to group comparisons by trials. SM indicates split mouth; RCT, randomized controlled trial.

a difference in failure rates between implants inserted using high and low torque in minipigs (RR, 2.05; 95% CI, 0.19–21.71; Fig. 2).

The %BIC was a variable analyzed by some selected animal studies. Figure 4 summarizes the qualitative evaluation of the %BIC outcome data. Five animal studies contributed with 12 comparisons to the meta-analyses on %BIC. A large between-study variation in effects was observed (I^2, 81.6%; *P*, 0.000; Fig. 4), so that we only depicted the predictive interval for illustrative purposes. The wideness of the predictive interval indicated that we are very unsure about the best estimate for BIC for a future animal study. We found no significant evidence about the correlation between torque values and %BIC, although some studies demonstrated a positive association between high insertion torque values and %BIC during the first days of implant healing.

Discussion

We identified 4 human and 6 animal studies of typically poor methodological quality, although incomplete reporting hampered the full appreciation of the study designs. The qualitative and quantitative evaluation through meta-analyses did not reveal any evidence favoring either high- or low-torque implants for our outcomes of interest: bone resorption, implant failure, and %BIC.

The current review was based on a systematic search of the literature according to explicit keywords and selection criteria. We used a protocol to guide RoB assessments with tools that accounted for the differences in designs included. An experienced systematic reviewer checked all RoB assessments. Although we followed sound methods to conduct our review, the conclusions are hampered by the poor overall body of evidence identified.

The necessity of adequate torque insertion values when immediate load is scheduled was first suggested, some years ago, by Ottoni et al,[5] which demonstrated that insertion torque was associated with the potential risk of implant failure in immediate loading protocols, which can be decreased by 20% per 9.8 Ncm added. Trisi et al[23] demonstrated, *in vitro*, that increasing the insertion torque peak could reduce the amount of implant micromobility (directly measured). Higher value of insertion torque is therefore expected to be associated with better implant primary stability *in vivo*.

Trisi et al,[22] comparing, *in vivo*, implants inserted with low torque (mean

10 Ncm) with implants insert with high torque (mean 110 Ncm) demonstrated higher bone apposition and secondary stability (reverse torque maximum value) in the second group without bone resorption and implant failure.

Other authors suggested that high insertion torque values (>80 Ncm) are necessary in immediate loading procedure[6] and do not cause bone resorption or implant failure.[8–10] Khayat et al[7] reported, in a controlled prospective clinical trial in humans, that the use of high insertion torque, up to 176 Ncm, did not prevent implant osseointegration and did not cause marginal bone loss.

Two studies[14,15] of 10 analyzed reported similar osseointegration amount (% BIC) in implants inserted in dog mandible irrespective of the insertion torque value, hypothesizing that a high implant insertion torque value is not necessary.

Only 1 study by Duyck et al,[11] to our knowledge, indicated that high insertion torque could probably lead to an excessive bone compression and to a subsequent peri-implant bone loss. It is important to focalize that, in that study, the authors compared 2 different implant macrodesigns and the bone loss observed could be related to the different neck geometry and/or implant site preparation instead of insertion torque values. The implants in the control group were different from implants in the test group and, for this reason, this study had poor evidence. The same authors, in a subsequent study,[21] demonstrated no negative impact on the biological process of osseointegration in implants inserted with high torque (>50 Ncm) with respect to the low-torque group (<10 Ncm).

Rizkallah et al[24] confirmed that the insertion torque undoubtedly played an important role in the primary stability and successful osseointegration of implants and they concluded that there seems to be no correlation between insertion torque and implant failure above 35 Ncm threshold of insertion torque.

Statistically higher early osseointegration rate (%BIC) at 2 weeks after implant insertion (in dog) was demonstrated by Campos et al[25] in implants inserted in undersized bone sites (median torque value of 70 N/cm) compared with implants inserted in oversized bone sites with lower torque insertion values (median value of 15 N/cm).

The minimum torque value that allows one to obtain clinical success, even in case of immediate loading, is a topic not clarified from the international literature because authors do not agree about the torque threshold level for clinical success.

A recent systematic review and meta-analysis,[26] that evaluated implants inserted with a torque ranging from 20 to 45 Ncm, concluded that when this torque range is used, there are no differences in implant failure rate between immediate and delayed loading. Another systematic review and meta-analysis recommended, for immediate loading protocol, a minimal insertion torque of 30 Ncm.[27] Ottoni et al,[5] on the other hand, demonstrated that every 9.8 Ncm of insertion torque added causes a significant decrease of implant failure rate (of about 20%) in immediate loading procedure. Cannizzaro et al[6] reported 7 implant failures among 50 implants inserted with insertion torque ranging from 25 to 35 Ncm.

Results from a recent meta-analysis[28] of high dental implant torque value effects on marginal bone resorption also demonstrated no statistically significant differences between high and conventional torque values in terms of effects on peri-implant bone loss.

The present review, however, clarifies that no significant differences in peri-implant bone resorption or survival rate are detected between titanium implant inserted with high or low insertion torque and highlighted that the overall body of evidence is weak, mainly because of the use of RoB in the individual studies, large clinical and statistical between-study variation, and imprecision.

CONCLUSION

The present review systematically evaluated the association between high insertion torque values and greater incidence of marginal bone resorption and higher implant failure rate, while performing an RoB assessment of both human and animal studies. We observed a high RoB in nearly all studies, a relatively small numbers of implants, and large clinical and statistical differences in between-study heterogeneity.

The number and type of studies did not allow statistical analyses to explore the effects of follow-up duration, implant design, or other potentially prognostic factors. Nevertheless, our systematic review summarized the best evidence published so far, concluding that there are no significant differences in marginal bone resorption or implant failure between dental implants inserted with high or low insertion torque values.

DISCLOSURE

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

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