Review Article

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Bone Response to Standard SLA and Modified SLA Dental Implant Surfaces: A Systematic Review and Meta-Analysis

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ABSTRACT

Background: To review the literature on bone response to standard SLA and modified SLA dental implant surfaces, the present review addresses the following focus question: in patients who receive dental implant treatment, does the use of modified SLA implants compared to standard SLA implants results in the better bone to implant contact and implant stability quotient?

Materials and Method: Electronic searches were conducted on PubMed/MEDLINE on studies published until 2018 to collect information about the effect of modified SLA and standard SLA dental implant surfaces. Eligibility criteria included clinical human and animal studies, randomized controlled trials and prospective studies, which evaluated dental implants, with both standard SLA and modified SLA implants in the same study.

Result: Out of 139 articles, six studies were included in this systematic review and meta-analysis was conducted. The combined results showed no significant differences after the two outcomes evaluated that implant stability quotient and bone-implant contact, respectively. Studies included concludes that BIC% at the early stage of healing, i.e. at two and four weeks was significantly high for modified SLA implants. But at around eight weeks, no significant difference was found between both the groups.

Conclusion: Within the limitations of this systematic review and meta-analysis, we concluded that there was no significant difference found between the standard SLA and modified SLA implant surfaces.

Keywords: Implant surface, bone response, modified SLA implants, implant stability, systematic review, meta-analysis, osseointegration.

INTRODUCTION

Brånemark et al. introduced a fresh era of research on shapes and materials of dental implants. But it was not until the last decade that the focus of biomedical research shifted from implant geometry to the osteoinductive potential of implant surfaces [1]. Various implant systems are available in different shape, surface material, surface topography and surface chemistry. These are the important factors which influences bone integration [2].

The topography of titanium surfaces has been investigated for dental implant applications in the past 15 years [3]. The primary objective of experimental researches was to determine whether new micro rough titanium surfaces could increase bone apposition relative to original implant surfaces. There are various methods which have been used to produce micro rough titanium surfaces, including sandblasting, acid-etching, or combinations of these [4]. Among these new surfaces,

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the sandblasted and acid-etched (SLA) surface demonstrated enhanced bone apposition in histomorphometry studies [5,6], and higher removal torque values in biomechanical testing [7-9].

The most widely used commercial techniques for the surface treatment are sandblasting and acid etching (SLA), and plasma spray coating of hydroxyapatite. Wennerberg reported that the optimal size of blasting media is 75μm for alumina particle in vivo study [10].

Surface chemistry is another key variable for peri-implant bone apposition since it influences surface charge and wettability. Increased wettability enhances the interaction between the implant surface and the biologic environment [11]. The chemically modified sandblasted, large-grit and acid-etched surface (SLActive, Institute Straumann) was introduced to the market in 2005 and was an innovative approach to the well-known sandblasted, large-grit, acid-etched (SLA) surface. The process involves rinsing under protective N2 conditions and subsequent storage in isotonic NaCl, leading to improved surface chemistry and greatly increasing the hydrophilic properties of the surface[12]. Since there is lack of systematic studies on standard SLA and modified SLA implant surface in the aspect of osseointegration, i.e. bone to implant contact and implant stability, the aim of this study is to investigate the efficacy of newly developed SLA surface treatment technique. Therefore, it's necessary to take a systematic review of present publications, with regard to the response of bone to modified SLA dental implant in comparison with standard SLA dental implant surface, to identify whether the modified SLA dental implant has clinical superiority and to develop recommendations for future research. Objective and Rationale: To review the literature on bone response to standard SLA and modified SLA dental implant surfaces, in patients who receive dental implant treatment, does the use of modified SLA implants compared to standard SLA implants results in the better bone to implant contact and implant stability quotient.

MATERIALS AND METHODS

This systematic review was written and conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement.

Focus Question:

The focus question was developed considering the Population, Intervention, Comparison, and Outcome (PICO) elements: In patients who receive dental implant treatment, does the use of modified SLA implants compared to standard SLA implants result in the better bone to implant contact and implant stability quotient? (P: patients with; I: implant treatment; C: comparison between modified SLA and standard SLA implant surface; O: bone to implant contact and implant stability quotient)

Selection criteria:

Eligible studies were included in this systematic review if they met the following inclusion criteria:

Inclusion criteria:

1. Only articles related to standard SLA and modified SLA implant surface were included.
2. Only full-text articles were included.
3. The inclusive criteria of the search were limited to articles written in English only.
4. Animal studies as well as human reports (randomized or not, prospective, retrospective, cohort or case series trials, systematic reviews, literature reviews, meta-analysis, comparative studies, observational studies) appraising the impact of modified SLA implant surface on bone and osseointegration.
5. The additional inclusion criterion for study selection was studied with ≥10 patients or animals.
6. Only published studies were included.

Exclusion criteria:

1. Studies composed of languages other than English were excluded.
2. Articles unrelated to the topic of SLA implants were excluded.
3. Studies not meeting any of the inclusion criteria were excluded from the review.

Source of data and search strategies:

The present systematic review and meta-analysis were designed based on the PRISMA guidelines. A broad electronic search of PubMed/ MEDLINE databases was performed for articles published without any limitation of date of publication. Articles written in English only were included, with a focus on peer-reviewed dental journals. The following keywords were used in the search strategy: "SLA dental implants", "implant surface", "bone response", "modified SLA implants", "osseointegration", "systematic review", "meta-analysis."

The titles and abstracts were first read by both the authors for identifying studies meeting the eligibility criteria. The articles which fulfil the inclusion criteria were included for the full-text reading. If there was any disagreement regarding the inclusion or exclusion of the selected articles, it was resolved by a discussion between reviewers.

Outcome Variables:

The primary outcome variable was determined by the success rate, as presented in the selected articles. Secondary outcome variables were the number of parameters used to define success, such as implant stability, bone to implant contact, and healing period.

Assessment of study Quality:

Following the selection of eligible studies on the basis of inclusion and exclusion criteria, studies were rated on their quality. Two independent reviewers evaluated all the included studies. Any disagreement between the reviewers was solved by discussion. Specific study-design-related information such as randomization (if applicable), patient and site characteristics, patient selection, intervention, evaluation method, outcome, and follow-up was individually assessed for all included publications. The risk of bias was defined as Low, Medium, or High.

RESULT

Screening process:

The searches from the electronic databases (PubMed/MEDLINE) yielded 139 relevant articles for consideration. After duplicates discarded, only 28 records were continued. The review of the titles and abstracts resulted in 21 articles identified as full-text articles, and 7 of them were also excluded as they were not the full-text articles and were potentially irrelevant. Then 15 full-text articles were also excluded as they were not following the inclusion criteria of the study. Finally, 6 eligible articles were included in this review. Out of these 6 studies, three are human studies, and three are animal studies. The characteristics of the included studies are presented in (Figure 1).

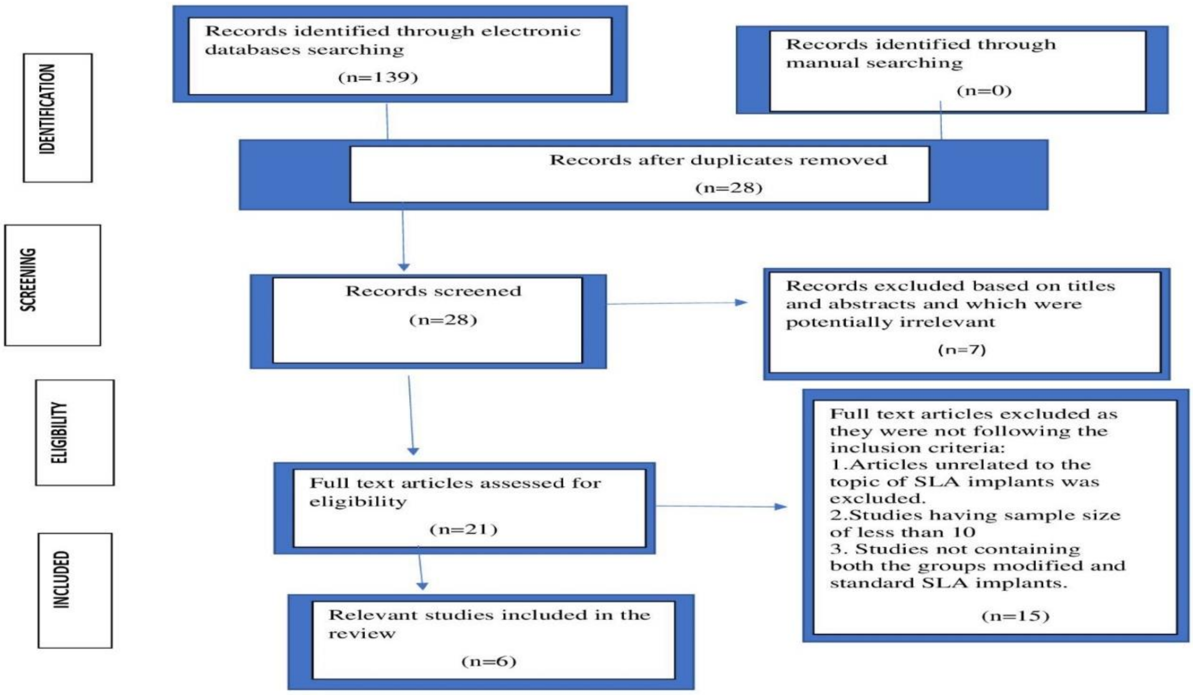

Fig 1: PRISMA flow chart detailing the literature search and the relevant studies retrieved.

Description of the Studies:

Study design

Two articles are randomized control trials, and remaining are the case studies. All the articles were published from 2003 to 2011. All the studies were identified as prospective studies. Data analysis of all the included studies was done and mentioned in Table 1. Forest and funnel plot was made for meta-analysis of included studies.

Table 1: Data analysis of all the included studies.

Authors name	Year of publication	ISQ of standard sandblasted large grit and acid etched implants	ISQ of Mod. Sandblasted, large grit and acid etched implants	BIC Mod. Sandblasted, large grit and acid etched implants	BIC with standard sandblasted, large grit and acid etched implants
Buser D et al.	2004			81.91 ± 3.59b	66.57 ± 8.14
Lai HC et al.	2009			64.58 (14.76)	76.43 (15.21)
Abdel-Haq et al.				64.39 _ 21.2	80.64 _ 13.89
Khandelwal N	2011	79.3 ± 1.1	79.1 ± 0.9		
Karabuda	2010	55.94 _ 5.95	55.40 _ 5.2		
Oates	2007	60.5±7.5	60.1 ±6.8		

Main outcomes of the included studies:

Bone Implant Contact:

The forest plot for the bone-implant contact utilized three studies. The result included the studies which have measured the BIC of both the groups the modified SLA and standard SLA implant surfaces. The heterogeneity in the result i.e. I^2 value is 0.00 and chi-square 0.18. The mean difference in Bone implant contact was 15.16, and the test shows the Z value of 5.63 and the p-value of 0.92. (Figure 2)

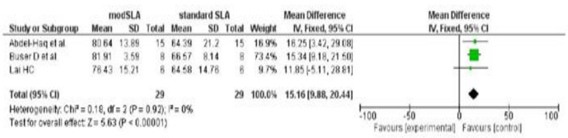

Fig 2: Forest plot showing studies which have measured the bone to implant contact between modified SLA and standard SLA implant surface.

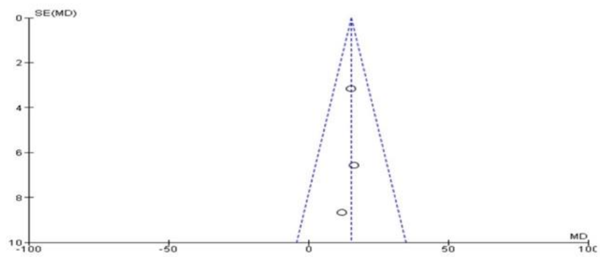

Figure 3: Funnel plot showing bone to implant contact between modified SLA and standard SLA implant surface of included studies.

Implant Stability Quotient:

The forest plot for the implant stability quotient included three studies. The result included the studies which have measured the ISQ of both the groups the modified SLA and standard SLA implant surfaces. The heterogeneity in the result, i.e. I^2 value is 0.00, and chi-square is 0.39. The mean difference in implant stability quotient was 0.16, and the test shows the Z value of 0.57 and the p-value of 0.82 (Figure 4).

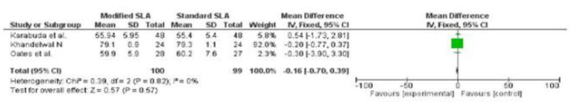

Fig 4: Forest plot showing studies which have measured the implant stability quotient between modified SLA and standard SLA implant surface.

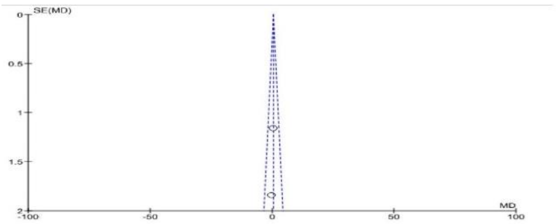

Fig 5: Funnel plot showing implant stability quotient between modified SLA and standard SLA implant surfaces of included studies.

Publication bias:

Funnel plot for both the outcomes bone-implant contact and implant stability quotient showed that all three studies were close to the CI (confidence interval) area margin and demonstrated certain asymmetry in the bone-implant contact, suggesting publication bias regarding both the groups during the follow-up period (Figure 3,5).

DISCUSSION

In this systematic review, via meta-analysis, we attempted to combine the human and animal studies to determine the effect of two surfaces of implants (the modified SLA and the standard SLA) on bone response and implant stability quotient. However, the surface quality of implant can also be a parameter to promote earlier loading of dental implants (M.M. Shalabi)[13]. Based on various experimental data which used SLA implants that showed reduced healing period with the new surfaces than the healing periods of 3-6 months that had been the standard in the past clinical practices (Adell et al. 1990; Zarb and Schimitt 1990; Merickske-Stern et al. 1994, 2002; Behneke et al. 2000,2002; Buser et al. 1997, 1999; Weber et al. .2000)[14-19]. Conclusions are unanimous as to the similarity in all the six studies which we analyzed.

No significant differences were found in the forest plot after analysis of the two outcomes evaluated that implant stability quotient and bone-implant contact (Df:2 [95%CI -0.70 -0.39], p=0.82); (Df=2 [95%CI -5.11 -28.81] p=0.92), respectively. This justifies the conclusions by the authors of the included studies.

Karbuda et al. compared the success rate and survival rate, changes in the stability, marginal bone loss and peri-implant parameters of early loaded standard and modified SLA implants. They placed around 96 standards and modified SLA implants in the jaws of 22 patients and used resonance frequency analysis to measure the stability of implant at the time of surgery and after 1,3 and 6 weeks. They concluded that the modified SLA implants at the loading stage show reduced bone loss at a marginal level and improved stability of implants. Also, a positive survival rate was shown by both the groups at the end of 15 months follow up[20].

Khandelwal N et al. conducted a randomized control trial to evaluate the capacity of standard SLA and modified SLA dental implants to improve the healing of implants and osseointegration in diabetic patients. They took 24 patients and placed 48 implants of both the groups. They measured implant stability quotient at the time of implant placement and at 2,3,4,6,8,10,12 and 16 weeks after the placement of the implant. They found no significant difference between the standard SLA and modified SLA implant surface[21].

Oates et al. also conducted a randomized controlled trial on around 31 patients to examine the implant stability changes with a chemically modified SLA implant surface over the 1st six weeks following the implant placement. No significant difference was found between the stability of both control and test implants i.e. the modSLA and standard SLA implants at the time of placement and after 6 weeks[22].

Lai HC et al. did an experimental study in dogs for evaluation of apposition of bone across the standard SLA and modified SLA implants at sites with circumferential gaps of different sizes. Bone apposition for both the surfaces showed the same pattern by the histomorphometric results. They concluded that BIC% at early stage of healing i.e. at two and four weeks was significantly high for modified SLA implants. But at around 8 weeks no significant difference was found between both the groups[23].

Buser et al. did an experimental study in miniature pigs to examine the apposition of bone around modified and regular SLA dental implants. These two groups have different surface chemistry but a similar topography. This study concluded that greater BIC% is seen with modified SLA group in comparison to regular SLA group in the early stages of healing and same results, i.e. no significant differences between the groups were seen at eight weeks[24].

Abdel-Haq et al. conducted an experimental pilot study in sheep to compare the bone integration and implant stability characteristics of modified and standard SLA dental implant surfaces. They placed a total 30 implants in tibiae of three sheep followed by resonance frequency analysis and insertion torque value were measured at 3 and 6 weeks after implant placement. This study concluded that higher bone to implant contact and stability was achieved at an early stage of healing with modified SLA implant group, and no significant difference was found after six weeks of healing[25].

After analyzing all the included studies, we found that the conclusions of each study were almost similar. That is why after the meta-analysis of our study, the heterogeneity within our studies was too low, almost 0%.

The main limitation of the studies evaluated was that they were having a short follow up period, and the sample size was also very less. In fact, very few studies are done to compare both the groups, i.e. the modified SLA and standard SLA implant surface. At review level, incomplete retrieval of identified research was there leading to bias and at outcome level also, as the studies were very few, so the risk of bias was more. This was, therefore the main limitation of our meta-analysis, which was not able to show a significant difference between the standard SLA and modified SLA dental implant surface, although acceptable heterogeneity was stated in both the outcome variables evaluated with minimal values for both bone to implant contact and implant stability quotient(I^2=0%). Hence, we recommend that additional studies are required with a larger sample size and longer follow up periods to further corroborate this treatment concept for dental implants.

CONCLUSION

Within the limitations of this systematic review and meta-analysis, we concluded that there was no significant difference found between the standard SLA (sandblasted, large grit, acid etched) and mod SLA implant surfaces. Additional long term, well piloted, randomized controlled studies are required before establishing the long-term predictability of modified SLA implants in reducing the bone healing period by improving the bone to implant contact and enhancing the stability of the implant.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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