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Review article

Comparison of external and internal implant-abutment connections for implant supported prostheses. A systematic review and meta-analysis

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ABSTRACT

Objective: The systematic review and meta-analysis aimed to answer the PICO question: "Do patients that received external connection implants show similar marginal bone loss, implant survival and complication rates as internal connection implants?".

Data: Meta-analyses of marginal bone loss, survival rates of implants and complications rates were performed for the included studies. Study eligibility criteria included (1) randomized controlled trials (RCTs) and/or prospective, (2) studies with at least 10 patients, (3) direct comparison between connection types and (4) publications in English language. The Cochrane risk of bias tool was used to assess the quality and risk of bias in RCTs, while Newcastle-Ottawa scale was used for non-RCTs.

Source: A comprehensive search strategy was designed to identify published studies on PubMed/MEDLINE, Scopus, and The Cochrane Library databases up to October 2017.

Study selection: The search identified 661 references. Eleven studies (seven RCTs and four prospective studies) were included, with a total of 530 patients (mean age, 53.93 years), who had received a total of 1089 implants (461 external-connection and 628 internal-connection implants). The internal-connection implants exhibited lower marginal bone loss than external-connection implants ($P < 0.00001$; Mean Difference (MD): 0.44 mm; 95% Confidence interval (CI): 0.26–0.63 mm). No significant difference was observed in implant survival ($P = 0.65$; Risk Ratio (RR): 0.83; 95% CI: 0.38–1.84), and complication rates ($P = 0.43$; RR: 1.15; 95% CI: 0.81–1.65).

Conclusion: Internal connections had lower marginal bone loss when compared to external connections. However, the implant-abutment connection had no influence on the implant's survival and complication rates. Based on the GRADE approach the evidence was classified as very low to moderate due to the study design, inconsistency, and publication bias. Thus, future research is highly encouraged.

Clinical significance: Internal connection implants should be preferred over external connection implants, especially when different risk factors that may contribute to increased marginal bone loss are present.

1. Introduction

Dental implants are a favorable treatment modality for partially or totally edentulous patients [1]. The success of the prostheses along with bone level stability and soft tissue health maintenance around dental implants are critical components for long-term success of implant therapy [2]. According to Albrektsson et al. [3] success criteria established as acceptable comprised an average bone loss of 1.5 mm during the first year in function and of less than 0.2 mm annually in the subsequent years without clinical sign of peri-implant infection.

The implant-abutment connection design seems to be an important factor in modulating bone level changes in implant-supported reconstructions [4]. Marginal bone changes around implants with different connection types have been attributed to several etiological factors, such as biomechanical factors that increase the stress at marginal bone tissue and potentially contribute to alveolar bone resorption [5]. Moreover, biological factors such as peri-implant accumulation of inflammatory cells at the implant-abutment interface may contribute to

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marginal bone loss [6].

Although there is a plethora of marketed implant designs, implant-abutment connection designs may be classified into two main groups: external and internal connections [7]. The external hexagon implants are the most widely used external connections. They have been in use since the early era of modern implantology, through the Branemark implant system. Although widely used today, this connection type has some drawbacks, including abutment micromovement, which has been associated with mechanical and biological complications [8,9].

Internal connections were designed to reduce the complications found in external connections and long-term clinical data support this assumption [10]. When internally connected, implant-abutment mechanical complications such as screw loosening and fracture are reduced, while stress dissipation is enhanced around the implant [5]. A systematic review reported a higher incidence of technical complications for externally connected implant systems compared with internal connections [11]. However, the European Association for Osseointegration Consensus Conference, suggested that more randomized clinical studies were needed to confirm these findings [12]. In particular, more research is required to evaluate the differences in marginal bone loss between implant systems, since secondary failure of implants is often preceded by marginal bone resorption, which can progress to peri-implantitis and contribute to implant failure [13].

Thus, the aim of this systematic review and meta-analysis was to evaluate the influence of external and internal implant-abutment connections by means of the following null hypotheses: (1) there are no differences between external and internal connections in terms of marginal bone loss; and (2) there are no differences in terms of implant survival rate and complications (mechanical or biological) between the different implant-abutment connections.

2. Materials and methods

2.1. Registry protocol

This systematic review was structured based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist [14], in accordance with models proposed in the literature [15–17]. The methods for this systematic review were registered on the international prospective register of systematic reviews (PROSPERO—CRD 42016053196).

2.2. Eligibility criteria

The population, intervention, comparison, outcomes (PICO) approach was used to address the question: “Do patients that received external connection implants show similar marginal bone loss, implant survival and complication rates as internal connection implants?” According to these criteria, the population comprised patients rehabilitated with dental implants; the intervention was rehabilitation with internal connection implants; and the comparison was with patients who received external connection implants. The primary outcome evaluated was the marginal bone loss around the implant, while the implant survival and complication rates were considered as secondary outcomes.

Eligible studies should present the following characteristics: (1) randomized controlled trials (RCTs) and/or prospective; (2) studies with at least 10 patients; (3) studies that compared both external and internal connection implants in the same report; and (4) studies published in English.

The exclusion criteria were: (1) *in vitro* studies, (2) animal studies; (3) case series or case reports; (4) retrospective studies; (5) biomechanical studies; (6) patients or data repeated in other included articles; and (7) studies that evaluated only one connection type (external or internal) without a comparison group.

2.3. Information sources and search strategy

Two independent authors (C.A.A.L. and J.F.S.J) conducted an electronic search of PubMed/MEDLINE, Scopus, and the Cochrane Library for articles published before October 2017 using the search terms: “internal connection and external connection and dental implant OR external and internal and dental implant OR Morse taper and external connection and dental implant OR internal and external and conical and dental implant”.

To complement this search, the same researchers manually searched for articles published in journals of specific areas: *Clinical Implant Dentistry and Related Research, Clinical Oral Implants Research, International Journal of Oral and Maxillofacial Implants, International Journal of Oral and Maxillofacial Surgery, Journal of Clinical Periodontology, Journal of Dentistry, Journal of Oral and Maxillofacial Surgery, Journal of Oral Implantology, Journal of Oral Rehabilitation, Journal of Periodontology, and Periodontology 2000*. In addition, OpenGrey (www.opengrey.eu) was used to search gray literature.

Initially, studies were selected and classified according to the eligibility criteria based on the title and the abstract of the articles. To make a decision regarding inclusion of studies with insufficient data in their titles and abstracts, the full manuscript was obtained. A third author (E.P.P.) analyzed all differences in choices between the investigators and consensus was reached through discussion.

2.4. Data collection process

One of the authors (C.A.A.L.) collected relevant information from the articles, and a second author (J.F.S.J.) reviewed all the collected information. A careful analysis was performed to check for disagreements among the authors, and a third author (E.P.P.) settled all the disagreements between the investigators through discussions until consensus was reached. The variables collected from the articles were as follows: author; study design; number of patients and implants; mean age; system, diameter and length of the implant; retention system; connection type; follow-up; complication; marginal bone loss (mean/standard deviation); and implant survival rate.

2.5. Risk of bias

Two investigators (C.A.A.L. and F.R.V.) assessed the quality and risk of bias of the RCTs included in this systematic review using The Cochrane Risk of Bias Tool which checks for selection bias (random sequence generation and allocation), performance bias (blinding of participants and personnel), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data), reporting bias (selective reporting), and other bias (bias from other sources). The risk of bias for non-RCTs (prospective) was assessed using the Newcastle-Ottawa scale [15,17], which is based on three major components for cohort studies: selection, comparability, and outcomes [18].

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was used to assess the quality of evidence for each outcome across studies. The GRADE assessment is based on the study design, inconsistency, indirectness, imprecision, and publication bias. According to GRADE, the rating quality of evidence is rated into four categories, high, moderate, low, and very low, which are applied to a body of evidence in the evaluated outcome, but not to individual studies. Furthermore, the GRADEpro Guideline Development Tool (www.gradepro.org), was used to perform a summary of the findings [19–21].

2.6. Summary measures

The meta-analysis was based on the inverse variance (IV) and Mantel–Haenzel (MH) methods. Marginal bone loss was considered the continuous outcome and evaluated using the mean difference (MD).