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Histological features of peri-implant bone subjected to overload

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ABSTRACT

Purpose: The aim of this review has been to investigate the histological findings of bone structure surrounding implants subjected to excessive load.
Materials and methods: Clinical and pre-clinical histological studies that observed overloaded intraoral implants were included.
Results: All included studies ($n = 15$) were conducted on animals. Most of them failed to find pathological alteration in the microstructure of bone surrounding overloaded implants. Overload and infection alone may induce bone loss, but related lesions have different and peculiar features.
Conclusions: The different histological features observed around implants subjected to overload or to ligature-induced peri-implantitis may indicate a specific pathogenetic mechanism for overload or infection-induced loss of osseointegration. The clinical significance of these findings should be confirmed in human studies.

Contents

1. Introduction

Loading the bone tissue during physiologic masticatory function regulates the remodeling of peri-implant tissue (Greenstein et al., 2013). When the applied force has the potential to cause permanent deformation or damage to the structure or its support, overloading occurs (Laney et al., 2007).

In implant dentistry, the effect of occlusal overloading on the loss of osseointegration is still a controversial issue. Some recent reviews were designed to examine the role of excessive and adverse masticatory load in peri-implant bone loss (Naert et al., 2012; Chambrone et al., 2010; Chang et al., 2013). These studies did not resolve this issue since the available data in the literature were too limited. Therefore, the question of whether the occlusal overloading by itself is able to induce peri-implant bone loss and

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thus implant failure still remains. Histological evidence may help to answer this question, since it contributes to understanding of the pathogenetic mechanism of bone resorption under excessive mechanical stress. The aim of the present review has been to describe bone histological features around implants subjected to overload.

2. Materials and methods

This review was performed according to the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).

2.1. Types of studies

Clinical trials, randomized controlled clinical trials, case series as well as animal experimental trials, which had performed histological analysis and were published in English were included. No narrative or systematic reviews were considered.

2.2. Type of intervention

Clinical or pre-clinical studies that applied overload to osseointegrated implants placed in maxillary or mandibular bone were included.

2.3. Study selection

In this review, clinical and pre-clinical studies presenting histological descriptions of the peri-implant bone features after static and dynamic overload on osseointegrated implants were included. All types of histological assessments were included. No publication status was imposed. For clinical trials a follow-up of at least 6 months was required, including a measure of the occlusal overload and the assessment of overload as aetiological factor of the peri-implantal bone loss. All studies evaluating factors that increase the load transmitted to the implant–bone interface such as single vs. splinted implants, short vs. long cantilevers, small vs. large crown-implant ratios, misfitting prosthesis were also included. For the animal studies, only intra-oral experimental sites were considered.

No unpublished data were included. No narrative or systematic reviews were considered. In vitro studies, studies on immediately loaded implants, not measuring the overload and not assessing histologically the peri-implant bone status as consequence of the occlusal overload were excluded.

2.4. Outcome measures

The primary outcome was the histological assessment of static or dynamic overload on bone structure surrounding the osseointegrated implants.

Overload was defined as the application of forces that presumably exceed the physiological range in terms of intensity, direction or timing.

2.5. Information sources and search

Studies were identified by the Medline (Pubmed) electronic databases and the search was performed on articles published from the 1st January 1975 to the 22nd of June 2014.

Hand search by scanning reference lists of articles and consultation with experts in the field were performed. Authors were contacted in order to acquire missing information. To perform the research, the following key terms were applied to the database: oral OR dental AND implant$ AND (load OR overload OR excessive load OR force$ OR bruxism) AND (bone loss OR bone resorption OR implant failure$).

2.6. Study selection

One independent reviewer (GP) firstly excluded irrelevant records by their title and abstract. To be included in the review, the full-text of each remaining paper was evaluated by two independent reviewers (CD and GP); disagreements between reviewers were resolved by consensus.

2.7. Data extraction and management

To perform a statistical comparison between articles, studies that used similar protocols were selected and comparable data were extracted.

3. Results

A total of 3222 studies were identified in the database. After removing duplicates and records that did not fit the inclusion criteria, only 15 articles remained (see Fig. 1) (Miyamoto et al., 2008; Gotfredsen et al., 2001a,b,c, 2002; Hürzeler et al., 1998; Miyata et al., 1998, 2000, 2002; Ogiso et al., 1994; Heitz-Mayfield et al., 2004; Kozlovsky et al., 2007; Nagasawa et al., 2013; Isidor, 1997a,b). All included studies were performed on animals (seven on dogs) (Miyamoto et al., 2008; Gotfredsen et al., 2001a,b,c, 2002; Heitz-Mayfield et al., 2004; Kozlovsky et al., 2007), seven on monkeys (Hürzeler et al., 1998; Miyata et al., 1998, 2000, 2002; Ogiso et al., 1994; Isidor, 1997a,b), one on rats (Nagasawa et al., 2013) and had variable periods of observation from 1 week to 18 months as reported in Table 1. The included studies analyzed the bone response after static and dynamic overload, in healthy conditions or after experimental plaque induced peri-implant inflammation. Data from the studies were reported separately considering the type of load and the control or not of peri-implant inflammation. Most of the studies reported quantitative histological parameters such as: bone-implant-contact (BIC), bone density (BD), bone level and other histomorphometric measurements of the peri-implant defect (i.e. inflammatory connective tissue are, ICT) (Miyamoto et al., 2008; Gotfredsen et al., 2001a,b,c, 2002; Hürzeler et al., 1998; Miyata et al., 1998, 2000, 2002; Heitz-Mayfield et al., 2004; Kozlovsky et al., 2007; Nagasawa et al., 2013; Isidor, 1997a,b). Furthermore, few studies reported microscopic morphological aspects of peri-implant bone (Hürzeler et al., 1998; Miyata et al., 1998, 2000; Heitz-Mayfield et al., 2004; Kozlovsky et al., 2007; Nagasawa et al., 2013; Isidor, 1997a,b), and few studies evaluated the bone metabolism by means of fluorochromes (Miyamoto et al., 2008; Gotfredsen et al., 2001a,b,c, 2002).Due to the heterogeneity of data reported from the included studies, no meta-analysis was performed.

3.1. Static overload

In a dog model, 12 implants after 24 weeks of overload had similar peri-implant histological features, bone level, even greater bone density (from 70% to 76%) and bone-to-implant contact (66–67%) than unloaded sites (bone density 58%, BIC 59%) (Gotfredsen et al., 2001a). In a further study performed on 5 dogs, for a total of 20 implants loaded for 12 weeks and 10 unloaded implants, similar bone density was found in overloaded implants with mucositis (69.1%) and overloaded implants with ligature induced peri-implantitis (75.7%); on the contrary unloaded implants with ligature-induced peri-implantitis showed lower bone density (59%) and bone activity (Gotfredsen et al., 2002). Implants with experimental peri-implantitis had greater bone loss than those affected

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