Effects of dental implants on hard and soft tissues

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Chapter 1

General introduction and aim of the study

General introduction

There is an increasing demand for dental implant treatment. Several factors have contributed to the expansion of its area of application during the last decades, among which are improvements in implant design and surface properties. Dental implants have successfully been placed in the edentulous mandible and maxilla to provide anchorage for overdentures or full fixed prostheses for many years. During the last decade, they are more commonly applied in partially dentate patients too, both for the replacement of a single tooth or for multiple missing teeth in the anterior and posterior regions of the mandible and the maxilla. Although there is a great diversity of possible applications of dental implants in restorative dentistry, all interventions share the same common treatment goal: to restore and preserve function and aesthetics.

Regardless of the purpose for which the implants are applied, to some extent they will always exert an effect on the surrounding oral environment, especially on the hard and soft tissues. Dental implants can affect the peri-implant hard and soft tissues in their direct vicinity, but also that of adjacent teeth. In edentulous patients an indirect effect on tissues in regions more distant from the inserted implants, e.g. on the antagonistic jaw or, when the implants are placed in the interforaminal region, on the posterior regions of the mandible can be expected as well. This PhD study focused on the effects of dental implants on the hard and soft tissues in both edentulous and partially dentate patients.

In edentulous patients an implant-retained mandibular overdenture can greatly improve function and comfort (Boerrigter et al., 1995). Mandibular overdentures can be retained by a different number of implants, but usually two or four. Different attachment systems are applied. The most common is a bar attachment system for which the implants are inter-connected or attachment systems such as ball or magnet attachment systems, which leave the implants non-connected. It has been suggested that implants not only improve the retention and stability of the denture, but may also preserve the residual bony ridge (von Wowern & Gotfredsen, 2001; Kordatzis et al., 2003). As already stated, both two and four implants are commonly used in the interforaminal region of the mandible to support and retain an overdenture. Consequently, the design of the bar attachment systems is biomechanically different for these two options. An implant-retained mandibular overdenture on two implants allows more rotation of the denture compared to an overdenture on four implants. When four implants are used there is

a less resilient joint when the attachment clips are divided over three bars. As a consequence, the forces that are exerted on the posterior mandibular ridge through both treatment options seem different and may result in different degrees of posterior mandibular ridge resorption.

In addition to the effect of an implant-retained mandibular overdenture on the posterior residual ridge of the mandible, an effect on the resorption in the edentulous maxilla may be present as well. In previous studies it has been suggested that the chance of developing the so-called combination syndrome, that has been observed in patients with an edentulous maxilla opposing a shortened dental arch in combination with a prosthetic device in the mandible, increases in persons wearing mandibular implant-retained overdentures (Barber et al., 1990; Lechner & Mammen, 1996). Five symptoms commonly occur in the combination 'syndrome': extensive loss of alveolar bone in the anterior part of the maxilla, the development of fibrous or bony enlargements of the tuberosities, papillary hyperplasia of the hard palate, extrusion of the mandibular anterior teeth and reduction of mandibular bone beneath the mandibular distal extension of a removable partial denture. Comparable oral changes also may occur in patients wearing an implant-retained mandibular overdenture. As a result of the built-in possibility of rotation over the implant-retained mandibular overdenture a comparable unfavourable distribution of occlusal load of the posterior mandible and anterior maxilla may exist. However, in studies focusing on the maxilla contradicting results are reported. Some authors indeed observed significant bone resorption in the anterior maxilla in patients wearing an implant-retained mandibular overdenture (Barber et al., 1990; Kreisler et al., 2003), whereas others demonstrated a higher annual maxillary residual ridge resorption in patients wearing a conventional denture than in patients wearing an implant-retained mandibular overdenture (Jacobs et al., 1993; Abd El-Dayem et al., 2007). No long-term studies have been published evaluating the effect of an implant-retained overdenture in the mandible on the resorption patterns of the edentulous mandibular posterior and maxillary anterior residual ridge.

In addition to the indirect effect of implants on the edentulous jaws, dental implants might also exert a direct effect on the peri-implant hard and soft tissues. In this PhD study the peri-implant hard tissues in edentulous patients were evaluated by assessing the marginal peri-implant bone loss. It is presumed that whether or not and to which extent marginal bone loss will occur is related to implant design, density of bone, surgical trauma at implant insertion and at second-stage surgery, occlusal overload of the implant, apical migration of sulcular

epithelium in an attempt to isolate bacterial-induced infection or to establish a biological width, interruption of blood-supply, or development of a pathogenic bacterial biofilm (Assenza et al., 2003). When considering all of the above mentioned factors, the characteristics of the implant surface (smooth versus rough surface) and thus the location of the rough/smooth border as well as the location of the microgap have been considered to be major determinants of the preservation of marginal bone around implants (Hermann et al., 2000a; Hermann et al., 2000b; Todescan et al., 2002; King et al., 2002; Piattelli et al., 2003; Assenza et al., 2003; Hartman & Cochran, 2004; Hanggi et al., 2005).

As mentioned above, dental implants are a common treatment option for the replacement of one or more missing teeth in partially dentate patients today. In contrast to implants that are inserted in edentulous patients, implants in partially dentate patients not only interact with their surrounding soft and hard tissues but also with their neighbouring teeth. Even more so, if two adjacent implants are placed in the aesthetic zone of partially dentate patients, all issues regarding the effects of implants on the peri-implant hard and soft tissues coincide. In case of two missing adjacent teeth, not only the effects on the surrounding hard and soft tissues of the implant itself, but also on the neighbouring tooth and on the adjacent implant have to be considered. These issues result in a complex restorative challenge if implants are placed adjacently in the anterior maxillary region, where aesthetics play an important role.

The criteria for success of implants in the aesthetic zone involve the establishment of a soft tissue contour with an intact interproximal papilla and a gingival outline that is harmonious with the gingival silhouette of the adjacent healthy dentition (Choquet et al., 2001). The presence of interproximal papillae adjacent to single tooth implants is determined predominantly by the marginal bone level and the attachment level of the neighbouring tooth (Kan et al., 2003; Grunder et al., 2005; Ryser et al., 2005). Unlike around single-tooth implants, an inter-implant papilla between adjacent implants is not supported by the attachment level of a neighbouring tooth. In addition, the bone condition is frequently compromised. As a result of resorption, the characteristic interdental bone peak is often missing. Moreover, it is not uncommon that deficiencies of the horizontal or vertical hard tissues are to such extent that an augmentation procedure is required to allow for reliable implant placement at a location favourable for prosthodontic rehabilitation. Furthermore, the height of the soft tissue (the inter-implant papilla) between implants is often less than the height of the soft-tissue (the papilla) between

the implant and its adjacent tooth which might also complicate the aesthetic outcome. Thus, the placement of two adjacent implant-supported restorations is still considered a treatment of which it is difficult to establish a predictable harmonious aesthetic outcome (Tarnow et al., 2000; Kourkouta et al., 2009).

In an attempt to preserve the peri-implant hard and soft tissues and thereby making implant therapy in the aesthetic zone more predictable, several implant designs have been introduced in recent years. One of these solutions is the scalloped implant which was designed to maintain or create the interproximal bony peaks that support the overlying soft tissues in order to preserve or create papillae. The proximal scallops of the implant follow the contour of the alveolar bone crest which is lower on the facial and oral aspects but rises in the interproximal areas. The ultimate goal of the scalloped implant design, according to the manufacturer, is to minimise the remodelling seen around implants, thus improving the quality of survival by maintaining three-dimensional osseous and soft tissue contours (Wohrle, 2003).

If adjacent implants are placed, the inter-implant horizontal distance appears to be an important factor in the preservation of bone height. In case of a reduced inter-implant distance, loss of the crestal bone height can be expected (Tarnow 2000, Castaldo 2004, Kourkouta 2009). When the two missing adjacent teeth are an upper central and a lateral incisor, it is not uncommon that space is insufficient to allow for a sufficient horizontal distance between the implants on the one hand and between the implants and their neighbouring teeth on the other hand. An option to solve this restorative dilemma could be to place a single implant in the region of the central incisor and provide it with an implant crown and distal cantilever at the position of the lateral incisor. This option has not been evaluated in the literature so far.

Aim of this study

The overall aim of this PhD study was to gain insight into the direct effects of dental implants on peri-implant hard and soft tissues and the indirect effects on mandibular and maxillary residual ridge resorption in edentulous patients. The specific aims were:

- to assess posterior mandibular residual ridge resorption and peri-implant marginal bone changes following the use of two or four endosseous implants that stabilise mandibular overdentures over a period of 10 years (Chapter 2).
- to assess the effect of implant-retained mandibular overdentures supported by two or four

dental implants and conventional mandibular dentures on resorption of the residual ridge of the anterior maxilla and of the posterior mandible over a period of 10 years (Chapter 3).

- to assess marginal bone changes around implants used to support mandibular overdentures during five years of functional loading with special attention to the impact of the location of the rough/smooth border and the location of the microgap (Chapter 4).
- to evaluate clinical and radiographic parameters of two adjacent implant crowns in the maxillary aesthetic zone in a retrospective study with a follow-up of up to 9 years (Chapter 5).
- to assess the clinical and radiographic parameters of patients with two adjacent implant crowns in the maxillary aesthetic zone, treated with either two adjacent implants with a scalloped platform or with a flat platform in a one-year clinical trial (Chapter 6).
- to assess the clinical and radiographic parameters of patients with a missing central and lateral upper incisor who were treated with either one implant and a prosthetic restoration with a cantilever or two implants with solitary crowns in a one-year prospective pilot study (Chapter 7).

Chapter 1

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