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General introduction
Introduction
Currently, placement of dental implants is the treatment of choice to eliminate common problems reported by wearers of conventional complete dentures. Implants provide support, improve retention and stability of overdentures, and reduce or eliminate pain during mastication (1–3). Implants not just eliminate problems, they also clearly contribute to improvement of patient satisfaction and masticatory performance (4).

The success of overdentures can be valued addressing different outcome measures and using different measuring methods. Patient satisfaction is one of these outcome measures. Many studies on patient satisfaction with implant overdentures use questionnaires to rate whether patients are satisfied or not (5–7). For this purpose, a wide variety of questionnaires is available, either validated (8–12) or non-validated (13,14). Additionally, a variety of ways of measuring function as a parameter of satisfaction is reported. Amongst others, the treatment effect of implant overdentures can be evaluated by assessing chewing efficacy, bite force, muscle activity and muscle anatomy. The assumption is made that improvement in these items also reflects greater patient satisfaction (13,15,16). The outcome of the various methods to assess patients’ appreciation with regard to overdenture treatment has not been reviewed in detail, but is eagerly awaited.

When, in a particular case, implant overdenture treatment is a good option to improve function and patient satisfaction, the amount of bone available for reliable implant placement can be limited or insufficient. With the increasing demand for implant treatment and increasing patients’ expectations to minimize morbidity, there is pressure in implant dentistry to perform rehabilitations with implants placed in challenging sites such as sites with a low bone density and/or quantity. This condition is accompanied by an increase of presence of dehiscences or fenestrations at implant placement (17–19). When placing implants with adequate primary stability but no complete coverage by bone, a bone augmentation in the same session might be a solution; such approaches are commonly applied in routine clinical practice to prevent extra surgical sessions and morbidity. This applies especially to the severely resorbed maxilla, when implants are placed to retain an overdenture. It is not well known how implants, which were placed with a dehiscence or fenestration of the implant surface,
perform after an intermediate-term follow-up. It is meaningful to assess the peri-implant bone changes of implants placed with large and small dehiscences after five years.

When maxillary overdenture treatment is chosen, the question remains how many implants are needed? The amount of evidence with intermediate to long-term follow-up on this topic is limited. Based on the findings of a systematic review about how many implants are needed for overdentures (20) and the good results from a randomized controlled trial with a five year follow-up comparing six- and four-implant overdentures (21) the choice for four implants to support a maxillary overdenture seems reasonable. After determining the amount of implants, the attachment system could influence success too. Various attachment systems have been used successfully to retain implant-supported overdentures in recent years.

These systems can be classified as bars and solitary attachments (balls and locators® (Zest Anchors, Inc. homepage, Escondido, CA, USA)). Which system a dental practitioner and technician prefer is predominantly based on their experience, training and clinical outcomes (22). Overdentures with a bar attachment system are a therapeutic option that offers many advantages for patients with severely resorbed edentulous ridges (21). For mandibular overdentures bars are seen as the golden standard because of their good retention capacity, low maintenance costs and simple insertion and removal of the denture (23). The relative high initial costs are a disadvantage of the bar system. Additionally, there is some evidence that solitary attachments are more easy to clean by the patient than bars and that the soft tissues and bone are healthier because of this (24–26). Solitary attachments can be used with different matrices. Attachment design and the choice of material used for the retentive part of the matrix influence the friction grip and thus the need for aftercare (27). It has been reported that for mandibular overdentures ball attachments need more aftercare then bar attachments (28,29). However, an advantage of the solitary attachment system in comparison to the bar attachment system is that when maintenance, repair or replacement is needed, this can be done quickly, the procedures are straightforward and it can mostly be done chair side (30). Repair and replacement of a bar superstructure mostly takes more time and is more complicated. Besides initially solitary attachments are less costly.
When comparing ball and locator attachments in the mandible and maxilla, ball attachments have more prosthodontic complications than locator attachments (31). Therefore, it seems that the locator attachment system is financially more favourable than other ball attachments (32,33). No differences between ball or locator attachments for patient satisfaction and peri-implant parameters were observed after one year (34). For this reason the locator attachment system seems promising and is preferred over the ball attachment system. Locators might be more favourable than bars for financial, oral hygiene and easy handling and maintenance reasons. However, there is scant literature containing direct comparison of bars and locators for maxillary implant overdentures. More research on radiographic, clinical and patient-reported outcomes of both options is needed before an evidence-based choice can be made on which attachment system is preferred.

Besides radiographic, clinical and patient-reported outcomes, functional outcomes are a very important aspect as well. In most cases the main complaint of a patient is the disability to function. As a consequence it is important to know whether the masticatory performance of a patient with a maxillary overdenture on a locator attachment system is as good as the masticatory performance of a patient with a maxillary overdenture on a bar attachment system. A variety of methods is currently in use to measure masticatory performance. The degree of breakdown can be measured using real test foods (peanuts, carrots, etc.) (35–37) or artificial materials (e.g., Optosil® and Optocal®) (38,39). Of all these tests, the two-coloured wax mixing ability test is the best at discriminating between people with compromised masticatory performance (40) and seems the best to use to measure performance.

As well as radiographic, clinical, functional and patient-reported outcomes, the arguments to choose a specific treatment can also be based on costs and especially cost-effectiveness. The initial costs of the newer locator system are presumed to be lower. Thus, choosing the locator system could be a way to keep up with the rising health care costs in general. If costs are known of both attachment options, and especially which treatment is more cost-effective, insight can be provided into whether the more costly treatment option offers sufficient added value to the patient to outweigh additional costs. In case of similar effectiveness, it could help health care
insurance companies in deciding which therapies to reimburse and which not, to control expenditures.

Last but not least, it should be three-dimensionally possible to apply the chosen treatment option. For the bar and locator attachment system the applicability depends on available space. The interocclusal clearance needed for the locator attachment system is less than for the bar attachment system. Providing information about the treatment process and the use of digital planning software when assessing available space is a good way to help the practitioner to choose between the different possibilities for treatment.

Aim of the thesis
The general aim of the research described in this thesis was to assess the performance of maxillary overdentures supported by four dental implants with regard to patient satisfaction, masticatory performance, impact of implant dehiscences at surgery, clinical and radiographic outcome, costs and choice of attachment system.

The specific aims were:
- to systematically review the literature on overdentures, in order to assess the improvement in masticatory performance, bite force, nutritional state and patient satisfaction after overdenture treatment (chapter 2);
- to assess the 5-year treatment outcome of implants to support a maxillary overdenture with a large dehiscent implant surface at placement (chapter 3);
- to assess, in a randomized controlled trial, the one year peri-implant bone height changes, implant survival, overdenture survival, clinical scores, and patient satisfaction of maxillary four-implant overdentures with either bar or locator attachments (chapter 4);
- to assess, in a randomized controlled trial, the change in masticatory performance one year after maxillary four-implant overdenture treatment with either bars or locator attachments (chapter 5);
- to perform a cost-effectiveness study on bars or locators for maxillary four-implant overdentures (chapter 6);
- to describe, in two clinical reports, the reasons for choosing either bars or locator attachments for maxillary overdentures (chapter 7).
References


