The loss of remaining natural teeth and provision of artificial removable dentition is a major and irreversible procedure for the patient. The main limitations of artificial dentition in the form of conventional dentures are related to the poor retention and comfort of the mandibular denture and patients' inability to eat properly. Completely edentulous patients experience a considerable improvement when their conventional mandibular dentures are retained with endosseous dental implants.\textsuperscript{1-4} This therapeutic approach has been developed to such a degree that it is now considered the standard care of treatment for patients who complain of persistent looseness of their mandibular complete dentures. Specifically, mandibular overdentures supported by two implants placed in the interferaminal region are regarded as an acceptable and predictable treatment modality.\textsuperscript{5} This conventional 2-stage protocol is associated with a healing period of 3-6 months prior to functional loading.\textsuperscript{6}

Subsequent research investigated, however, whether this prolonged healing period was an absolute prerequisite and whether it could be shortened without compromising osseointegration.\textsuperscript{2} As a result, a shortened period between implant placement and prosthesis insertion was introduced to reduce treatment time.\textsuperscript{8} The terms early and immediate loading were presented to define these shortened healing periods after implant placement. Immediate loading of dental implants has been defined as loading within one week subsequent to implant placement.\textsuperscript{9} Several clinical investigations reported high survival rates for endosseous dental implants placed in the edentulous mandible and loaded immediately after placement.\textsuperscript{10,11} The ITI Conference Consensus stated that the literature supports immediate loading of microrough implants with mandibular overdentures.\textsuperscript{12} The proposed advantages of the immediate loading protocol are that it shortens treatment time, gives patients immediate functional benefits, reduces the number and length of office visits, and necessitates fewer provisional restorations. However, these advantages must be weighed against the risks of multiple simultaneous surgical and restorative procedures.

Initially, the use of four splinted implants in the interferaminal region was considered mandatory to achieve long-term favorable results.\textsuperscript{13} Nowadays, immediate loading of two implants to retain implant overdentures (IODs) is considered an acceptable treatment modality.\textsuperscript{14-16} However, a limitation of immediate loading treatment protocols is the diameter of the implants. In cases where the residual bone width is limited, patients need to undergo a bone augmentation procedure or extensive alveoloplasty before standard-sized implants can be inserted. As a rule, an implant of nearly 4 mm in diameter requires at least 6 mm of bone in a facial-lingual dimension for placement without grafting additional bone to augment the site.\textsuperscript{17}

An alternative to standard-sized implants in the edentulous mandible is the use of Mini Dental Implants (MDIs). They are manufactured as one piece and include an abutment designed for support and/or retention of a provisional or definitive prosthesis.\textsuperscript{18} This simplifies the restorative phase, resulting in reduced costs for the patient. The narrow
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diameter of the MDIs often allows a simplified insertion technique, involving placement without raising a flap. Although the MDIs have a reduced surface area compared with standard-sized implants, histology in miniature swine has indicated that MDIs are capable of achieving significant osseointegration after three months. The histomorphometric evaluation showed bone integration in all implants at three months (average bone-to-implant contact of 82%).

Initially, the MDIs were used for temporary prosthetic stabilization during the healing phase of standard-sized implants. Their success, however, has expanded their use. Subsequently, they have been used for long-term fixed and removable prosthetics. Further clinical research has indicated that IODs retained by MDIs might have the potential to become a successful alternative to the current standard implant treatment in the edentulous mandible (two-implant overdenture). One important parameter that determines long-term clinical success is the amount of marginal bone loss (MBL) around the implants. Changes that are beyond the normal limits can result in loss of bone anchorage of the implants. Clinical and radiographic outcomes of immediately loaded MDIs used for long-term stabilization of IODs as an alternative to standard-sized implants have already been published. For example, in a prospective study by Elsyad et al it has been shown that the peri-implant soft and hard tissue responses of immediately loaded MDIs supporting mandibular overdentures were favorable after three years of function. The vertical MBL reported in the aforementioned study was $-1.26 \pm 0.64$ mm 36 months after loading, and it was comparable to that experienced with standard-sized implants.

The survival rates of MDIs reported in the literature are also comparable to those of immediately loaded standard-sized implants. A retrospective study of up to five years showed a high survival rate of the MDIs used to retain mandibular overdentures.

As any other type of oral rehabilitation, the provision of implant-retained overdentures requires a regular and ongoing maintenance program to ensure long-term clinical success. Relining of a mandibular implant overdenture might occur more often in cases of immediately loaded MDIs because of the secondary healing of the soft tissue around the implants. Other prostodontic complications may include wear of the O-ring attachments, detachment of the metal housing, fracture of the mandibular overdenture and relining of the maxillary denture. This treatment modality therefore, may require a considerable amount of prosthetic maintenance and repair over time. Although studies report on prostodontic complications, it is difficult to make definitive conclusions since there is a lack of criteria related to a successful prostodontic outcome.

Besides clinical findings, patients’ perception on how implant treatment contributes to their quality of life and overall satisfaction is also relevant. Griffitts et al reported that patients experienced a great improvement five months post-operatively with regard to retention of the prosthesis, chewing ability, and comfort.
Summarizing, there is sufficient evidence to suggest that MDIs have the potential to be an adequate, simplified and cost-effective alternative for denture stabilization in the edentulous mandible. There is, however, a lack of randomized controlled clinical trials that compare MDIs with standard-sized implants used to retain mandibular overdentures.

**OUTLINE OF THE THESIS**

In this thesis we evaluated whether a relatively new treatment modality, the rehabilitation of the edentulous mandible with IODs retained by four MDIs, could be an alternative to the existing therapeutic approaches.

The first step (chapter 2) was to conduct a systematic review to evaluate whether there is a combination of number and diameter of implants and attachment system that provides the best clinical outcome in immediately loaded implants used to retain mandibular overdentures, opposed by a maxillary complete denture. For this purpose, a comprehensive search strategy was implemented with specific inclusion and exclusion criteria to identify related studies. The results of this review warranted a prospective study comparing standard-sized implants and MDIs to further assess the clinical performance of MDIs.

Thus, the next step involved a pilot study (chapter 3) in which we investigated the radiographic marginal bone level changes and patients’ satisfaction and quality of life levels of a treatment concept with four immediately loaded (the same day) MDIs, which were used to retain an IOD in edentulous patients. Based on the positive outcomes of the pilot study, a 1-year randomized trial was designed to assess and compare several aspects of rehabilitating the edentulous mandible with IODs retained by MDIs with an existing, documented treatment concept (chapter 4 and 5). The conclusions would help to determine whether it could be a successful alternative treatment modality for the edentulous mandible. The primary outcome was the marginal bone loss around the inserted implants. Secondary outcomes included the peri-implant soft tissue response and the aftercare needed (chapter 4). In addition to the clinical findings, patient-based outcomes were evaluated (chapter 5). In order to achieve this, general satisfaction ratings on a visual analog scale (VAS) as well as a denture-specific short version of the Oral Health Impact Profile (OHIP-20) questionnaire were used.

Regardless of the treatment protocol that is followed in order to convert a mandibular conventional denture to an implant overdenture, a thorough assessment prior to implant placement is of paramount importance. The radiographic evaluation as part of the initial examination can contribute to the selection of the most appropriate size of the inserted implants but can also significantly minimize the risk of complications during placement of
the implants. Various imaging techniques, such as panoramic radiographs and cone beam computed tomography (CBCT) can aid treatment planning in the edentulous mandible. Many clinicians limit themselves to the use of panoramic radiographs for the preoperative planning of implants, despite the inherent limitations of this technique. The use of CBCT might provide additional important information which can be used to minimize the risk of surgical complications. The decision, however, to proceed to cross-sectional imaging is not always straightforward, and should be based on clearly identified needs and the clinical and surgical requirements of the clinician. We considered it therefore clinically relevant to evaluate the diagnostic value of cross-sectional imaging as part of the treatment planning prior to fabricating mandibular overdentures that are retained by two implants placed in the interforaminal region (chapter 6).

Finally, in chapter 7 the main conclusions of the thesis are discussed, presenting the most important findings and attempting to outline the difficulties of carrying out this clinical study as well as to address its limitations.
REFERENCES


