Summary
Currently, placement of dental implants to support a mandibular or maxillary denture is the treatment of choice to eliminate common problems reported by wearers of conventional complete dentures. While there is a lot of knowledge regarding the performance of implant-supported mandibular overdentures, including the effect of patients’ satisfaction, implant survival, peri-implant health and number of implants needed to support such a denture, still some concerns remain regarding the performance of implant-retained maxillary overdentures (Chapter 1). Therefore, the general aim of the PhD research described in this thesis was to assess the performance of maxillary overdentures supported by four dental implants, with regard to patients’ satisfaction, masticatory performance, impact of implant dehiscences at surgery, clinical and radiographic outcome, costs and choice of attachment system.

In Chapter 2, the theoretical background of implant overdentures was addressed. It has been shown that oral function with removable dentures improves when dental implants are used for support. It is not yet set, however, what the impact of implant-retained maxillary overdentures is on masticatory performance, bite force, patients’ satisfaction and nutritional state as well as how to measure these parameters. Therefore, a systematically review of the literature was performed to explore outcome methods used to measure change in masticatory performance, bite force, patients’ satisfaction and nutritional state in patients with removable implant-retained dentures. Medline, Embase and The Cochrane Central Register of Controlled Trials were searched. Fifty-three of 920 found articles fulfilled the inclusion criteria. Most studies included mandibular overdentures; only three studies included maxillary overdentures. Implant-supported overdentures were accompanied by high patients’ satisfaction, but this high satisfaction was not always accompanied by improvement in general quality of life (QoL). Bite force improved, masseter thickness increased and muscle activity in rest decreased. Patients could chew better and eat more tough foods. No changes were seen in dietary intake, body mass index (BMI) and blood markers. Improvements reported after 1 year, remained stable with a slight decrease on the long run. The conclusion of this systematic review was that treating complete denture wearers with implants to support their denture improves their chewing efficiency, increases maximum bite force and clearly improves satisfaction. The effect on QoL is uncertain, and there is no effect on nutritional state.
In Chapter 3 a study is described in which the 5-year clinical and radiographic outcome of implants with a dehiscent surface at implant placement was assessed. For this study a total of 26 consecutive patients (mean age 61.6 years; SD 8.0 years) with at least one implant with a dehiscent implant surface of two thirds of the implant length on the labial side was included. All implants were placed to support a maxillary overdenture. The implants were placed with adequate primary stability and the dehiscent surface was covered with autologous bone, anorganic bovine bone and a resorbable membrane. Outcome measures were soft tissue conditions, change of radiographic marginal bone level and implant survival. Baseline data (at loading) were compared with 1-year and 5-year post loading data. Of the 116 implants, 40 implants had no dehiscence, 16 had a buccal dehiscence < two thirds of the implant length, and 60 implants had a dehiscence ≥ two thirds. The peri-implant tissues were healthy and 5-year marginal bone changes were well within normal limits (-0.4 mm; range: -0.8 to -0.1). One implant was lost during the osseointegration period. This study shows that even when implants are placed with a dehiscence ≥ two thirds of the buccal implant surface, favourable 5-year peri-implant health can be achieved provided these dehiscences are covered with autologous bone, anorganic bone and a resorbable membrane, and there is good initial stability of the implants.

To assess the treatment outcomes of completely edentulous patients with four-implant overdentures supported by either bars or locators, a 1-year, prospective randomized controlled trial was performed. For this randomized controlled trial, 50 edentulous patients were enrolled. One group of patients (n=25) received maxillary four-implant overdentures on locators and the other group patients (n=25) a maxillary four-implant overdenture on bars. Outcome measures were change in radiographic bone level, implant survival, overdenture survival, soft tissue conditions (plaque index, presence of calculus, gingiva index, sulcus bleeding index and pocket probing depth), patients’ satisfaction (denture complaints questionnaire, the Oral Health Impact Profile questionnaire (OHIP-NL49) and the general satisfaction score (GSS)). Follow-up was one year. It was observed that marginal bone loss was 0.58±0.71 mm for the locator group and 0.31±0.47 mm for the bar group. Implant survival was 96.7% and 97.9% in the locator and bar group, respectively. Overdenture survival was 100% in both groups. After 1 year, the bar group scored better on total OHIP-49NL and GSS for
the upper denture. Clinical indices and all separate item scores (denture complaints questionnaire and OHIP-NL49) were not different between the groups.

Masticatory performance with a maxillary four-implant overdenture was assessed in the same patients that were included in the study described in Chapter 4. All 50 patients had to complete a mixing ability test (MAI) and questionnaire about masticatory function before and 12 months after treatment (Chapter 5). Irrespective of being treated with a maxillary overdenture on bars or locators, MAI improved and scores on GSS, OHIP-NL49 and denture satisfaction were better.

From the studies described in Chapters 4 and 5, it was concluded that maxillary overdentures retained by bars on four implants opposed by a mandibular overdenture are accompanied by significantly less peri-implant marginal bone loss and more satisfied patients than maxillary overdentures retained by locators. Mixing ability was the same for all the patients (either maxillary overdentures on bars or locators), while patient reported masticatory performance was better for patients treated with maxillary overdentures on bars.

The differences in the assessed outcome variables of patients treated with a maxillary four implant overdenture on either bars or locators were small. Therefore, a cost-effectiveness study was performed to assess whether the groups differed (Chapter 6). The purpose of this study was to estimate the cost and to evaluate the cost-effectiveness of both four-implant maxillary overdentures designs in a Dutch hospital setting. To estimate the cost-effectiveness of both attachment systems, two different ratios were used, i.e., cost per gained OHIP-NL49 point and cost per gained Mixing Ability Index (MAI) point. Using opportunity costs, the total costs were €6312 (range: €5516 - €6893) and €4160 (range: €3676 - €4644) for the bar and locator overdenture treatment, respectively. Cost-effectiveness was €113 per OHIP point gained for the bar attachment system and €83 per OHIP point gained for the locators. Additionally, cost-effectiveness was €2.570 per MAI point gained for the bar attachment system and €1623 per MAI point gained for the locators. This study showed that up to one year after wearing a maxillary four-implant denture, the cost-effectiveness ratios are in favour of the locator overdenture with regard to the assessed outcome.
variables. From the probabilistic sensitivity analysis it can be concluded that, although in the base case the outcome is in favour of the bar overdenture, for the OHIP outcome the bar overdenture treatment is more effective for about only two thirds of the simulations. The outcomes cannot be valued, because no willingness to pay thresholds are known for the outcome measures used. As a result of the cost-effectiveness acceptability curves it can be said that the with respect to the OHIP outcome there is a probability of 95% that the bar overdenture is cost-effective when payers are willing to pay a maximum of €135/OHIP and for the locator overdenture this is €109/OHIP.

For the MAI outcome, these values are €4950/MAI for the bar overdenture and €2600/MAI for the locator overdenture. The choice for a particular treatment option, especially in dentistry, cannot only be based on cost-effectiveness, as clinical performance is another important factor as well. Moreover, the cost-effectiveness results presented in this thesis are reported only for the first year after placement of the maxillary overdenture. An assessment of the long-time cost-effectiveness of both maxillary four-implant overdenture designs is eagerly needed.

In Chapter 7, two cases treated with maxillary overdentures are described: one case with a bar overdenture and one case with a locator overdenture. The description of these cases was added because limited knowledge is present on planning of attachment systems in relation to available prosthetic space. Each system has its own advantages and disadvantages, but needs a specific amount of space. Planning was done digitally with planning software. These two case reports illustrate planning a bar attachment system and planning the use of locators.

Summarizing, maxillary overdentures on four implants with either a bar or locator attachment system result in more satisfied patients and are accompanied by healthy peri-implant conditions. The following considerations should play a role in the decision making for a maxillary overdenture on bars or locators:

- From the patient’s point of view, the maxillary overdenture is best supported by bars. However, a maxillary overdenture on locators also improves patients’ satisfaction significantly.
- From a clinical perspective, the bar overdenture is accompanied by
less marginal bone loss in the first year after placement, even though the difference with the peri-implant marginal bone loss accompanying the locator overdenture is very small.

- From a cost-effectiveness point of view, at least up to one year after placement of the maxillary overdenture, a bar overdenture is less cost-effective with regard to the oral health related quality of life and functional outcomes.