SUMMARY

A lost or congenitally missing tooth in the anterior region ('aesthetic zone') usually requires prosthetic replacement for functional and aesthetic reasons. The ultimate goal to strive for when restoring a missing anterior tooth is creation of a high quality restoration for the long-term, satisfying the criteria that reflect function and aesthetics. Dental implants have conquered a prominent role in contemporary dentistry when it comes to such replacements.

There are, however, factors that could affect the treatment outcome of single-tooth implants in the aesthetic zone. E.g., after implant placement and through time of function, it is accepted that some marginal bone around the implant will be lost. The level of the peri-implant marginal bone is related to the level of the peri-implant mucosa, which, in turn, is commonly considered as an important aspect determining the aesthetic outcome. Hence, loss of peri-implant marginal bone could affect the level of the peri-implant mucosa and with that the aesthetic outcome. Furthermore, marginal peri-implant bone loss might induce pocket formation, which could be unfavorable for long-term health of the peri-implant tissue. There is some evidence that the design of the implant neck might influence the amount of peri-implant marginal bone loss. As a result, various implant neck designs have been introduced for maximum preservation of marginal peri-implant bone.

Apart from the role of the implant neck design, the concept of immediate loading is object of study in recent implantology. Placement of an implant crown immediately after implant installation offers advantages for the patients compared to a conventional load-free healing period of several months. These include reduction of overall treatment time, avoidance of second-stage surgery and immediate comfort as there is no need for a removable prosthesis during the healing phase. However, immediate loading might also induce more risk, since the implant is disturbed by forces during healing, possibly affecting a successful osseointegration.

There is a paucity of well-designed trials addressing the effect of the implant neck design on the outcome of single-tooth implants therapy in the aesthetic zone. The same applies to trials investigating the efficacy of immediate loading of single-tooth implants in the aesthetic zone. Therefore, the general aims of this thesis were to compare the outcome of single-tooth implants in the aesthetic zone with three different neck designs and to compare the outcome of immediate loading with that of conventional loading, also for single-tooth implants in the aesthetic zone.

In chapter 2 the available literature on the efficacy of single-tooth implant therapy in the aesthetic zone is systematically reviewed. Studies reporting on implants replacing a missing anterior tooth (region 15-25) with natural adjacent teeth were
considered for inclusion. A distinction was drawn between immediate, early and conventional implant approaches. The methodological quality of eligible studies was assessed by two reviewers independently using specific study-design related assessment forms.

Out of 86 primarily selected articles, 19 studies fulfilled the inclusion criteria. Follow-up periods of included studies were relatively short (only four studies had a follow-up duration ≥ five years). A meta-analysis showed an overall implant survival rate of 95.5% (95% CI: [93.0 – 97.1]) after one year and minor marginal bone loss at one year after definitive crown placement (0.20 mm, based on five studies). A stratified meta-analysis revealed no differences in survival between immediate, early and conventional implant strategies. A low incidence of biological and technical complications was found. No differences in outcome measures were reported in clinical trials comparing immediate, early or conventional implant strategies. Unfortunately, no studies could be identified focusing on the effect of different implant neck designs or different implant types.

This review demonstrates that promising short-term results can be achieved for immediate, early and conventional single-tooth implant treatment in the aesthetic zone. However, it was found that in literature, important parameters including aesthetic outcome, soft-tissue aspects and patient satisfaction were clearly underexposed. The question whether immediate and early single-tooth implant procedures will result in comparable - or even better - treatment outcomes could not be answered due to lack of well-designed controlled clinical studies. The same applies to the question regarding the effect of the design of the implant neck on the outcome of therapy.

In chapters 3 and 4, the outcomes of single-tooth implants in the aesthetic zone with three different neck designs are compared for marginal bone level changes, clinical outcome measures, aesthetic outcome and patient satisfaction. A total number of 93 patients with a missing anterior tooth in the maxilla was randomly assigned to be treated with an implant with a 1.5 mm smooth neck (‘smooth group’), with a moderately rough neck with grooves (‘rough group’) or with a scalloped moderately rough neck with grooves (‘scalloped-group’). All implants were installed in healed sites and were loaded after three months with a provisional crown. Three months later, implants were restored with definitive all-ceramic crowns. After implant placement and at 6 and 18 months thereafter, clinical data and standardized radiographs and photographs were collected. Patient satisfaction was explored using a self-administered questionnaire.

Chapter 3 focuses on marginal bone level changes and clinical outcome. Significant differences in radiographic marginal bone loss were found between the
study groups. The scalloped group yielded significantly more radiographic bone loss from implant placement to 18 months thereafter (2.01 ± 0.77 mm) compared to the smooth group (1.19 ± 0.82 mm) and rough group (0.90 ± 0.57 mm). Furthermore, at 18 months follow-up, the scalloped group showed significantly deeper pocket depths and significantly higher bleeding scores. Besides, more complications of technical origin (e.g. porcelain fracture, crown mobility) occurred in the scalloped group during follow-up. Survival rates were 96.8% for the smooth group (1 implant lost) and 100% for the rough and scalloped groups. There were no significant differences in bone loss and clinical outcome between the smooth group and rough group and both these study groups showed favorable results as compared to what has been established in other studies on single-tooth implants in the aesthetic zone. Based on these findings, we recommend the use of either an implant with a 1.5 mm smooth neck or an implant with a rough neck with grooves for anterior single-tooth replacements in stead of using an implant with a scalloped neck design.

Chapter 4 focuses on the aesthetic outcome from a professional’s and patient’s perception. On photographs taken at one year after definitive crown placement (18 months post implant placement), the aesthetic outcome was assessed by two professionals using two objective aesthetic indexes (Pink Esthetic Score/White Esthetic Score (PES/WES) and Implant Crown Aesthetic Index (ICAI)). A 5-point Likert scale, ranging from very dissatisfied to very satisfied, was used to assess the aesthetic outcome from a patient’s perception. Furthermore, general patient satisfaction was explored using a Visual Analogue Scale ranging from 0 (very dissatisfied) to 10 (very satisfied). No differences in aesthetic outcome were found between the three implant neck designs. According to the professional’s assessments using the PES/WES and ICAI, respectively 79.3% and 62% of the crowns showed acceptable aesthetics. In 59.8% and 56.5% of the cases, acceptable mucosa aesthetics were found according to PES/WES and ICAI, respectively. A regression analysis showed that a pre-implant augmentation procedure was associated with less favorable objective aesthetics of the mucosa (according to the PES/WES, the most reproducible index). From a patient’s perception, more than 80% of the patients were satisfied about the aesthetic outcome of the crown and mucosa. This finding revealed that there is a discrepancy between the aesthetic appreciation from a professional’s and patient’s perception. General patient satisfaction was high (9.0 ± 1.0 out of a maximum of 10). This study shows that the aesthetic outcome of single-tooth implants in the aesthetic zone appears to be independent on the implant neck designs applied, but dependent on the need for pre-implant augmentation surgery.

In chapter 5 it is studied whether immediate loading of anterior single-tooth im-
plants is not inferior to conventional loading. A number of 62 patients with a single missing maxillary anterior tooth was randomly assigned to two study groups. In one study group, patients were treated with an implant that was restored with a non-occluding provisional crown within 24 hours (‘immediate group’). In the other study group, patients were treated with an implant that was restored according to a two-stage procedure at three months after implant placement (‘conventional group’). After the provisional phase, definitive all-ceramic crowns were made. Follow-up visits were conducted after 6 and 18 months post-implant placement. The primary outcome measure of this study was marginal bone level change as measured on standardised radiographs. Non-inferiority of immediate to conventional loading was considered established when the immediately loaded implants showed no more than 0.5 mm of mean marginal bone loss compared to conventionally loaded implants. Other outcome measures were survival, soft tissue aspects (probing pocket depth, plaque, bleeding, peri-implant mucosal level), aesthetic outcome (using PES/WES and ICAI) and patient satisfaction.

All implants had good primary stability (≥ 45 Ncm insertion torque). At 18 months post-implant placement, no differences in marginal bone loss were found (immediate group 0.91 ± 0.61 mm, conventional group 0.90 ± 0.57 mm). One implant was lost in the immediate group, three weeks after immediately loaded with a provisional crown. No implants were lost in the conventional group. There were no differences in probing pocket depth, plaque, bleeding and peri-implant mucosal level. Furthermore, the aesthetic outcome and patient satisfaction did not differ between both study groups.

Within the limitations of this study (sample size and follow-up duration), we conclude that immediate loading of single-tooth implants in the aesthetic zone is not less favorable than conventional loading. Since the concept of immediate loading offers advantages for the patient, this concept should be considered as a promising alternative to conventional loading. However, the concept of immediate loading has to be performed according to a specified protocol paying attention to adequate primary implant stability, a non-occluding provisional crown and careful patient instruction.

An immediate loading protocol of an anterior single-tooth implant is described in chapter 6. It is described how the provisional crown was made and how an optimal emergence profile was created by adjusting the provisional restoration. After the provisional phase, an impression was made with an individually fabricated impression post for an accurate reproduction of the established emergence profile. The final crown was a screw-retained all-ceramic crown consisting of an individual zirconia abutment. By implementing this protocol, an optimal definitive result could be achieved together with immediate patient satisfaction.
In chapter 7 a report of a trauma case is described in which an implant crown in the aesthetic zone was involved. The traumatic impact resulted in a palatal displacement of the implant crown. After careful examination and follow-up, it appeared that only the fixation screw was damaged, while the implant, crown and peri-implant tissues remained unharmed. The implant crown could easily be replaced on the implant using a new fixation screw.

The main research outcomes are discussed and general conclusions are drawn in chapter 8. It is concluded that for single-tooth replacements in the aesthetic zone, implants with a 1.5 mm smooth neck or a rough neck with grooves display less marginal bone loss and better clinical performance than implants with a scalloped rough neck with grooves. However, there were no differences in aesthetic outcome between the various types of implants studied. Furthermore, we conclude that the outcome of immediate loading of single-tooth implants in the aesthetic zone is not less favorable than conventional loading. Additional follow-up studies are needed to validate these conclusions for the long-term.