Chapter 1

General Introduction
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One of the treatment options to replace a missing tooth is the insertion of a dental implant. Dental implants are available in various surface characteristics, lengths, shapes and designs. The ultimate goal of any dental implant is to simulate the function of a tooth root. As it is not composed of natural body-own material it is of course a compromise, supporting a superstructure replacing the natural crown. Since the initial introduction of implants to dentistry, a lot has changed in treatment planning, treatment execution, the design of dental implants and their surface.

Directly after insertion of a dental implant a cascade of biological events occur during the bone healing process (Terheyden et al. 2012). The change in bone shape and consistency is a result of this bone healing process is, in contrary to a possible pathological bone loss (Cochran & Nevins 2012, Hermann et al. 2000, Hermann et al. 2001, Linkevičius & Apse 2008). Osseointegration is considered to be the phenomenon of direct apposition of bone on an implant surface, which subsequently undergoes structural adaptation in response to a mechanical load (Laney et al. 2008). Over time the shape of crestal bone around the implants changes both horizontally and vertically (Ericsson et al. 1996, Ericsson et al. 1995). One of the criterions for success of dental implant treatment is the amount of crestal bone change. Various factors, such as position of the implant-abutment interface, the position of smooth and rough implant surfaces, loading protocols and platform switching have been described to control and ideally minimize this remodeling process (Hanggi et al. 2005, Schwarz et al. 2013).

The implant-abutment interface (IAI) is the common contact surface area between an implant-abutment and the supporting implant. At this IAI a microgap is present and it is usually considered to be a source of irritation. The microbiome, which is present in this microscopic space, creates a chronic inflammatory response. Hence the connection of the implant to the abutments may influence the bone remodeling process (Cochran et al. 1997, Hermann et al. 2000, Hermann et al. 2001, Hermann et al. 2011). A systematic review of the literature on the

![Figure 1: Microgap.](image)
vertical position of the implant-abutment connection was performed. The location of the microgap changes which could influence the biological width. There is however lack of evidence to support any conclusions (Schwarz et al. 2013). A mismatch between the implant and a smaller diameter abutment relocates the implant-abutment interface horizontally. This idea was originally designed to trick the biological width from vertical to horizontal length (Hurzeler et al. 2007, Vandeweghe & De Bruyn 2012). This so-called platform switching between the abutment and implant is thought to contribute to the preservation of bone (Atieh et al. 2010). A meta-analysis, which studied the role of changing an implant-abutment to one with a smaller diameter (the platform-switch approach), showed that the epithelial connection was elongated (Atieh et al. 2010).

All dental implant systems make use of different drilling protocols, implant surface configurations, implant macro and micro geometries, prosthetic components, diameters and lengths. Furthermore according to the manufacturers guidelines most implant types are applicable for all indications. Prior to every treatment a surgical and prosthetic planning should be considered to ensure a well-prepared case. A critical part of this planning is the choice of implant design.

In general there is a choice between two design approaches: an epicrestal IAI (also called bone level implant) or supracrestal IAI (also called soft tissue level implant). There is however, no indication suggested by the manufactures for either of these implants. Both implant designs can be indicated in all situations. The design of the implant however is not the only parameter that might be responsible for the success of implant related treatment. There are patient specific aspects such as general health, site-specific hard- and soft-tissue characteristics and off course aftercare and maintenance in the long term that also influence treatment success. Furthermore surgical protocols, loading protocols, design of superstructure and for example the expertise of the care provider may also contribute to the health, esthetical and functional behavior of these implants.
A systematic review and meta-analysis of the current literature on the influence of the position of the implant-abutment interface could provide us with more insight. A PICO question was formed to address the issue; P: patients with loaded implants for a minimum of 1 year, I: Implant placed with prosthetic connection at bone level, C: Implant placed with prosthetic connection at soft tissue level and O: crestal bone level change between placement and minimal one year of loading. Is there any difference on crestal bone change in implants with the implant-abutment connection at crestal bone level or above? (Chapter 2) The primary outcome of this literature study are changes in crestal bone levels at either mesial, distal or both sides on the control and test implants. Significant more crestal bone change was seen, radiographically, in the soft tissue level group ($P < 0.00001$). Within the limitations of this study, dental implants with the prosthetic connection at bone level showed significant less crestal bone changes after one year of loading when compared to implants with the prosthetic connection above the crestal bone level. However, none of these implants had the same macro geometrical shape, were loaded under the same conditions and all fixed dental prosthesis were cemented. So, these results should be interpreted with caution. Despite the fact that there is a statistical significant difference between both types of implants on micrometer level, measured on an X-ray. This study leads to the question: May we conclude from these facts that bone level implants are subjected to less bone loss when compared to soft tissue level implants? (Chapter 3)

Another factor, which has been extensively described in the literature, are implant-loading protocols. Loading protocols have changed since Brånemark in Sweden and Schroeder in
Switzerland introduced the first dental implants. Proceedings of the third International Team for Implantology (ITI) consensus meeting defined loading categories according to the time of implant placement (Weber et al. 2009). Conventional: a minimum of 3 months, early: at least 48 hours and no later than 3 months and immediate: within 48 hours after implant placement. The early loading definition is however tenuous as the timespan could make a significant difference in stages of healing (Attard & Zarb 2005). The primary stability; a site-specific characteristic that is determined by many factors such as the bone quality, bone type, drilling protocol and implant design, degrades over time when osteoclast and osteoblast activities start to remodel bone. The secondary stability is the ingrowth of cells on the surface of the implant. Many studies measured the stability of implants using Resonance frequency analysis (RFA). Most of these studies tested the RFA at the time of implant placement and after 3 months of healing (Andersson et al. 2013, Bogaerde et al. 2010, Stoker & Wismeijer 2011, Zembic et al. 2010). Furthermore an Implant stability quotient (ISQ) value, which varies between 1-100, might provide information to safely load the implant (Manresa et al. 2014). This is within certain boundaries and, on the other hand, only of value, when there are previous reference values. As the primary stability is a site-specific characteristic that increases during healing; a variation in secondary stability value can be expected. Close RFA follow-up during this healing period could be of interest as it shows the stability track of individual implants. The question has risen: could there also be a difference between bone and soft tissue level implants? (Chapter 4)

Yet another factor influencing bone remodeling is the anatomical situation involving bone and surrounding tissues. One of these site-specific characteristics is flap thickness. This has been associated with postoperative bone loss. A significantly higher amount of bone loss was observed in tissue thickness less than two mm (Linkevičius et al. 2009). More studies showed comparable results (Caram et al. 2014, Linkevičius et al. 2014, Puisys & Linkevičius 2015, Schrott et al. 2009, Vervaeke et al. 2014). In most of these human and canine studies a statically significant cut-off value was seen at 2 mm of soft-tissue thickness surrounding the dental implants. Also a statistically significant difference was seen when using a allogenic membrane to thicken the soft-tissue after implant insertion when soft-tissue is thinner than 2 mm. Furthermore a study by (Schwarz et al. 2013) demonstrated a higher occurrence of peri-implantitis when soft-tissue thickness was reduced (less than 2 mm) when compared to thicker mucosa. If this initial softtissue thickness provides a more stable future for the implants and related restoration which effect can be expected when comparing bone and soft tissue level implants? (Chapter 5)
Patients’ satisfaction and Quality of Life are other factors that could be affected by dental treatments. The Oral Health Related Quality of Life (OHRQoL) may measure these. OHRQoL has been the subject of many publications in the past. (Awad et al. 2014, Babbush 2012, Borges et al. 2011, Fillion et al. 2013, Furuyama et al. 2012, Gates et al. 2014, Grover et al. 2014, Harris et al. 2013, Jabbour et al. 2012, Jofre et al. 2013, Kuoppala et al. 2013, Misumi et al. 2015, Mumcu et al. 2012, Oh et al. 2016, Swelem et al. 2014, Tan et al. 2014, van der Meulen et al. 2008, van der Meulen et al. 2012, Wismeijer et al. 2013, Zembic & Wismeijer 2014). The main goal of any dental treatment should be carefully fulfill the wish of the patients to improve the OHRQoL. The OHRQoL changes negatively when a tooth is lost. A dental implant could be part of the treatment to enhance the OHRQoL. The result of an implant treatment should be functional, in the absence of pain and inflammation and esthetical pleasing; thus all influence the OHRQoL. In this study we used the Oral Health Impact Profile 14 to evaluate the effect of implant placement in patients with a unilateral shortened dental arch or a unilateral diastema. (Chapter 6)

Considering all the above-mentioned dilemmas, we designed a prospective, randomized clinical trial where bone level and soft tissue level implants are loaded under similar circumstances and conditions, in the hope this could provide us with some answers. The implants should have the same macro geometrical shape and the fixed dental prosthesis should be screw-retained instead of cement retained preventing bias to cement related issues. Therefore the aim of this thesis is to address various issues related to the vertical displacement of the implant-abutment interface, e.g. bone and soft tissue level implants. Is the crestal bone affected observing geometric similar implants with the prosthetic connection at the crestal bone level or 2,5 mm above? (Chapter 3) What is

Figure 5: Macro geometrically similar implants as were used for this study.
the pattern of development in implant stability during osseointegration in implants with the prosthetic abutment connection at the crestal bone level or 2.5 mm above? (Chapter 4) Does the initial mucosal thickness affect the crestal bone level around bone and soft tissue level implants? (Chapter 5) What is the effect of an early-loaded 2 implant supported fixed partial denture in patients with a Kennedy Class II and III on the OHRQoL? (Chapter 6)
References


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