CHAPTER 1

General introduction
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Single implant treatment in the maxillofacial aesthetic zone has been shown to be a highly reliable treatment procedure for the rehabilitation of a single failing tooth or a single missing tooth (den Hartog et al. 2008, 2011, Jung et al. 2012, Lang et al. 2012, Slagter et al. 2014, Arora et al. 2017). Meanwhile, in times of an increasing demand for an ideal aesthetic outcome of a failing or missing single tooth in harmony with the neighbouring teeth, the focus in research has shifted from implant survival, which has been proven to be very high, towards how to preserve hard and soft peri-implant tissues (Araújo et al. 2015, Tettamanti et al. 2016, Cosyn et al. 2017). This shift in focus has occurred, because recession of the mid-buccal mucosa and the resulting unpleasing aesthetics of the peri-implant mucosa are still rather frequently observed (Raes et al. 2011, Cosyn et al. 2016, Tonetti et al. 2017, Mangano et al. 2017).

To achieve a pleasing aesthetic outcome, it is presumed that the mid-buccal peri-implant mucosa has to be supported by a correctly three-dimensional positioned implant with a sufficient buccal bone volume (Merheb et al. 2014, Chappuis et al. 2017a). It is not uncommon that there is not sufficient buccal bone volume, as the bone remodelling process following tooth removal has led to a substantial vertical and horizontal resorption of the alveolar ridge, especially at the buccal aspect (Merheb et al. 2014, Araújo et al. 2015). This resorption, in particular when horizontal resorption is severe, results in a deficient buccal bone wall, thus limiting an optimal soft tissue support. As a result the aesthetics of the peri-implant soft tissue are challenged (Chappuis et al. 2017a).

Immediate implant placement and provisionalisation has been proposed to provide immediate support to peri-implant hard and soft tissues in order to limit recession of the mid-buccal mucosa and thus results in more favourable aesthetics (De Rouck et al. 2009). Several studies have demonstrated, however, that the post-extraction resorption process is not countered by immediate implant placement (Araújo et al. 2006, Vignoletti et al. 2012, Merheb et al. 2014). In fact, immediate implant treatment is often accompanied by inherent presumed potential risk factors influencing ridge resorption and mid-buccal mucosa recession, viz. a thin or pre-existing defect of the buccal bone wall, implant positioning too far to the buccal and a thin gingival biotype (Chen & Buser 2014, Del Fabbro et al. 2015, Morton & Pollini 2017). To reduce the effects of bone resorption after tooth removal on peri-implant soft tissues in immediate single implant cases, it has been recommended to place an implant at least 2 mm palatally from the buccal socket wall of the fresh extraction alveolus in combination with grafting of the implant-socket gap (Merheb et al. 2014, Lin et al. 2014, Cardaropoli et al. 2015). Additionally, according to several case series, thickening of the mid-buccal mucosa by applying a connective tissue graft at implant placement has been suggested to further limit recession of the mid-buccal mucosa, especially in the presence of a thin gingival biotype (Kan et al. 2017).
2005, 2009, Chung et al. 2011, Tsuda et al. 2011, Rungcharassaeng et al. 2012). Two randomized controlled trials (RCTs) assessing the additional effect of connective tissue grafting in immediate implant treatment showed a better preservation of the mid-buccal mucosal level (Yoshino et al. 2014, Migliorati et al. 2015), but both studies showed limitations regarding patient selection and measuring changes of the mid-buccal mucosal level. Additionally, both a retrospective study and a 5-year prospective study reported an increased recession of the mid-buccal mucosa despite connective tissue grafting (Cosyn et al. 2016, Kolerman et al. 2016). Therefore, more insight into the added value of connective tissue grafting needs to be established.

When immediate implant placement and provisionalisation after extraction of a single failing tooth is not possible because of insufficient bone volume to provide implant placement in a correct three-dimensional position with sufficient primary stability, implant placement has to be delayed (Buser et al. 2017). Moreover, to limit the dimensional changes of the extraction socket with a large buccal bone defect as a result of physiological bone remodelling after tooth removal, it has been recommended to graft the extraction socket (alveolar ridge preservation) combined with sealing the socket with a mucosa graft. This combined procedure has been shown to favour aesthetics (Raghoebar et al. 2009, Jung et al. 2013, Barone et al. 2013). Although alveolar ridge preservation with the application of a mucosa graft significantly reduces the amount of bone remodelling, the obtained degree of reduction is highly variable due to local and systemic factors. Therefore, bone loss as well as soft tissue changes still occur and have to be studied in more detail (Barone et al. 2013, Avila-Ortiz et al. 2014, Natto et al. 2017).

If a tooth has been removed without efforts to perform an alveolar ridge preservation procedure, physiological bone resorption may result in a substantial reduction of the alveolar ridge, especially at the buccal aspect of the maxillary anterior region (Merheb et al. 2014, Araújo et al. 2015). This outcome may, at least in part, underlie the insufficient aesthetic outcome that has been reported for implant treatment in the aesthetic region (Chappuis et al. 2017a). Local augmentation of the buccal bone wall at implant placement in naturally healed alveolar ridges with guided bone regeneration (GBR) has been shown to effectively increase the buccal soft tissue contour, resulting in less recession of the mid-buccal mucosa, also on the long term (Benic & Hämmerle 2014, Benic et al. 2017, Chappuis et al. 2017b). On the contrary, pre-implant augmentation of a naturally healed buccal bone wall may be accompanied by a less beneficial aesthetic outcome (den Hartog et al. 2013). The best pre-implant bone augmentation procedure, if any, to obtain the best aesthetic result later on needs further study. Replacement of a single failing tooth with an implant placed in a preserved alveolar ridge or replacement of a single missing tooth with an implant and guided bone regeneration still might result in a deficient peri-implant mucosa due to soft tissue changes. Thickening of the
buccal peri-implant soft tissue by means of a soft tissue grafting procedure might compensate for this deficiency (Thoma et al. 2009, Buser et al. 2017). The application of a connective tissue graft at implant placement has been demonstrated to effectively increase the soft tissue contour, resulting in a better aesthetic outcome (Wiesner et al. 2010, De Bruyckere et al. 2015, Hanser & Khoury 2016, Stefanini et al. 2016). Besides, connective tissue grafting showed to be able to limit recession of the mid-buccal mucosa (Schneider et al. 2011, Stefanini et al. 2016).

Soft tissue augmentation with connective tissue is currently considered the golden standard for thickening the mid-buccal peri-implant mucosa (Thoma et al. 2014a, b). To reduce patient morbidity as a consequence of the harvesting procedure of connective tissue, a xenogeneic collagen matrix has been introduced (Sanz et al. 2009, Froum et al. 2015). First results are promising in terms of increasing soft tissue thickness. Thus, a xenogeneic collagen matrix may serve as a proper alternative to connective tissue grafting, but is in need of further evaluation, especially in terms of the ability to limit recession of the mid-buccal mucosa (Lorenzo et al. 2012, Cardaropoli et al. 2012, Jepsen et al. 2013, Thoma et al. 2016, Zeltner et al. 2017, Maiorana et al. 2018). While there are an increasing number of studies assessing the effect of soft tissue grafting, especially of a xenogeneic collagen matrix, in single implant treatment, most studies reported in the literature focus on the effect on soft tissue volume instead of the change in mid-buccal mucosal level (amongst others, Wiesner et al. 2010, Lorenzo et al. 2012, De Bruyckere et al. 2015, Froum et al. 2015, Hanser & Khoury 2016, Thoma et al. 2016, Zeltner et al. 2017, Maiorana et al. 2018). However, in particular the change in mid-buccal mucosal level to a more apical position compared to the contralateral tooth and neighbouring teeth can have a detrimental effect on the aesthetic outcome.
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Aim of the thesis

The general aim of the research described in this thesis was to gain insight into the effect of soft tissue grafting on the condition and aesthetics of the peri-implant tissues in single implant treatment in the aesthetic zone. The specific aims were:

• to assess whether the bucco-palatal implant position, gingival biotype, platform-switching and pre-implant bone augmentation affect the level of the mid-buccal mucosa (Chapter 2);
• to assess the effect of connective tissue grafting on the mid-buccal mucosal level of immediately placed and provisionalised single implants in the maxillary aesthetic zone (Chapter 3);
• to assess the effect of connective tissue grafting on the preservation of the mid-buccal mucosal level, change in mid-buccal mucosal volume and change in buccal bone thickness in single immediate implants in the aesthetic zone (Chapter 4);
• to describe a surgical approach for removal of primary and impacted secondary canines combined with immediate placement and provisionalisation of an implant (Chapter 5);
• to assess whether grafting the buccal peri-implant mucosa at implant placement, either with connective tissue or a xenogeneic collagen matrix, results in less mid-buccal mucosa recession (Chapter 6);
• to compare the treatment outcome of single implants placed in preserved alveolar ridges versus non-preserved alveolar ridges combined with connective tissue grafting on the mid-buccal mucosal level, bone loss, peri-implant aesthetics and patient satisfaction (Chapter 7).
References


Chapter 1


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