

A New Method to Monitor Long-Term Tissue Stability and Pink Esthetics Around Endosseous Dental Implants: Ultrafast Optical Sectioning Technique for 3D Soft Tissue Mapping

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Abstract

Radiologic evaluation has been considered the gold standard to evaluate the stability of the bone around an endosseous dental implant and peri-implant tissue health in general. However, the radiological parameters does not assess morphology and soft tissue volumes variations.

There is an urgent need then to improve our diagnostic field for the long-term maintenance of health and esthetics around dental implants. In fact, while advanced peri-implant bone loss is easily recognized by radiographs, soft tissue changes cannot be detected by a radiological analysis. Furthermore, early alteration of the mucosa is often site specific and discrete and then difficult to recognize. Soft tissue mapping by using an ultrafast sectioning technique may be considered as a non invasive approach to evaluate the long-term stability of the peri-implant mucosa as well as its thickness, creeping, volume maintenance and pink esthetics. The main advantage of using a 3D soft tissue mapping is the possibility to monitor the dynamic changes of the peri-implant soft tissues which are critical to prevent early esthetic and biological complications.

Master casts were scanned by using an ultrafast sectioning technique at the time of the delivery of the final restorations as well as at 1, 3, 6 and 12 months. By overlapping the digital models dynamic soft tissue changes were recorded.

The ultrafast sectioning technique for 3D mapping may be a valuable and non invasive diagnostic tool to assess the status of the peri-implant mucosa as well as the pink esthetics.

Keywords: *Endosseous; Dental Implants; Soft Tissue Mapping*

Introduction

Since their introduction endosseous dental implants have become an integral part of modern dentistry. While the long-term success rate for the endosseous implants is good, it is of importance to periodically monitor patients who received implant therapy. Maintenance therapy may vary depending on patient's ability to maintain a good oral hygiene and among patients with different risk of complications. The dental professional's role in monitoring and maintaining patients has already been described [1]. It is imperative that the tissues around implants be monitored at regular intervals to diagnose biological complications and intervene at early stage.

It is generally known that clinical parameters such as probing depth, clinical attachment level, bleeding upon probing, plaque and gingival indices, state of the mucosa, width of the keratinized gingiva, sulcular fluid, suppuration, pain and implant mobility should be

periodically evaluated. However, their prognostic value is currently unknown. In general, progressive changes seem to be more important when referred to probing depths. Increasing pocket depths may represent early signs of mucositis or peri-implantitis [2]. Also, predictors of disease such as thin tissues, the presence of specific periopathogens, symptoms and the absence of lamina dura should be considered during the maintenance phase [3].

The overall success rate have been defined by specific criteria [4] which include the assessment of mobility, radiolucency, vertical bone loss less than 0.2 mm per year, no sign of pain, infection and paresthesia. The radiologic evaluation has been considered as the best methodology in order to assess the maintenance of peri-implant tissue volumes. Periodic peri-apical radiographs should be taken to evaluate peri-implant vertical and horizontal bone loss [4]. However, these criteria does not include morphology and soft tissue volumes variations. Furthermore, it should be considered that while advanced peri-implant bone loss is easily recognized by radiographs, early alteration of the mucosa are often site specific and discrete [5]. Soft tissue mapping by using an ultrafast sectioning technique may be considered as a non invasive approach to evaluate the long-term stability of the peri-implant mucosa as well as its thickness, creeping and volume maintenance.

Aim of the Study

The aim of this manuscript is to propose a new approach for the evaluation of the peri-implant soft tissue and the maintenance of pink esthetics.

Materials and Methods

Master casts were made of dental stone (GC Fujirock Type 4, GC Corp., Tokyo, Japan) after taking impression with polyether impression material (Impregum Penta Super Quick Medium Body) at the time of the delivery of the final restorations as well as at 1, 3, 6 and 12 months. An intraoral scanner (Trios® 3 Cart wired, 3Shape, Copenhagen, Denmark) and an indirect digitalization of models have been applied. Data were acquired by an ultrafast sectioning technique based on a structured illumination thus creating multiple digital models obtained by casts. By overlapping the models it was possible to evaluate minimal morphological changes of the peri-implant mucosa but also create virtual sagittal cuts and precisely measure the thickness as well as the height of the circumferential peri-implant soft tissues including the papillae.

Presentation of a Case

A 45-year-old female patient presented with pain and no suppuration on the inferior border of the right zygomatic bone (Figure 1). Her medical history reported no significant systemic diseases except for a mild hypotension. The patient at the time of treatment was not under any medication.



Figure 1: Pre-op clinical view showing gingival recession, a reduced periodontium, and overhang restoration on tooth #15.

The radiographic and clinical examination revealed the presence of an endodontic failure and peri-apical pathosis on tooth #15 (Figure 2 and 3), biologic width violation, generalized advanced attachment loss as well as generalized mucogingival deformities. The treatment planning was based on initial non surgical periodontal treatment, re-evaluation at 4 weeks, extraction of teeth #17 and 15, esthetic osseous surgery, simultaneous implant placement in area #15, Guided Bone Regeneration (Figure 4) and immediate loading. The final full ceramic CAD-CAM crown were delivered after 4 months of healing (Figure 5).

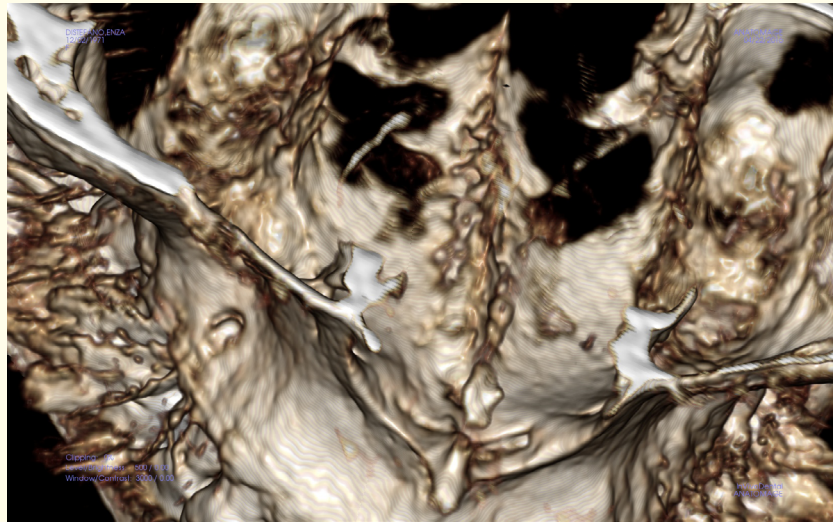


Figure 2: The 3D reconstruction is showing a fenestration of the buccal plate due to the failing endodontic treatment on tooth #15.

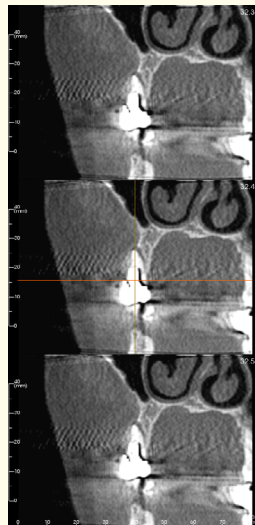


Figure 3: The sagittal cuts are showing an endodontic lesion, the buccal perforation and the residual bone volume.

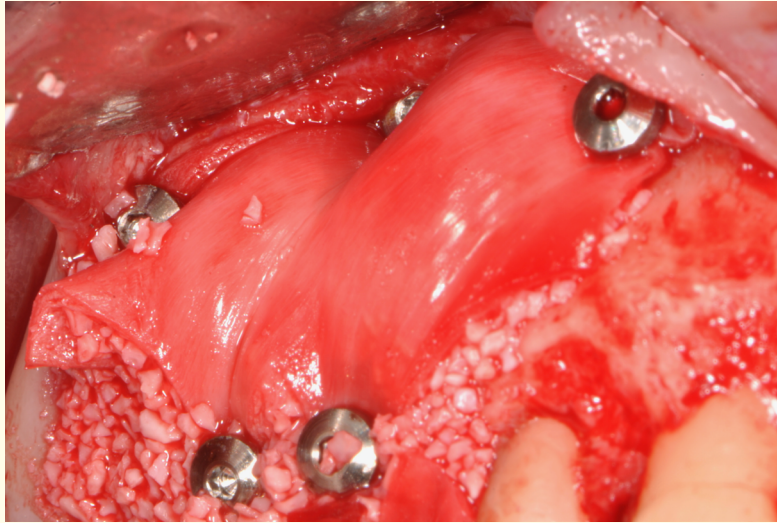


Figure 4: After extraction and immediate implant placement, a simultaneous Guided Bone Regeneration and immediate loading was performed.



Figure 5: Final full ceramic restorations.

Results

At 1 year of loading the sagittal cuts showed the stability of the augmented tissues (Figure 6) and a stable and dense buccal bone balcony of about 4 mm of thickness. The soft tissue morphology was well preserved (Figure 7). However, the digital soft tissue mapping

reported detailed tissue changes on the distal, mesial and medial aspect of the endosseous dental implant. The distal papilla increased of 1.02 mm on the palatal aspect during the 12 months of follow up (Figure 8). During the same period of observation the distal col increased of 1.17 mm (Figure 9) and the buccal aspect of the distal papilla of 0.68 mm (Figure 10). On the mesial papilla it was reported an increased thickness of 1.2 mm (Figure 11) on the palatal aspect, a decrease of 0.89 mm (Figure 12) of the papilla height and a bucco-lingual collapse of 0.65 mm (Figure 13). During the first month a collapse of 0.87 mm on the medial aspect was observed (Figure 14). However, after 3 months from the delivery of the final restoration a peri-implant soft tissue maturation was registered. The increase of thickness was 0.77 mm compared to the initial level of the medial mucosa. A total gain of 1.64 mm of buccal soft tissue thickness was achieved in 2 months of tissue maturation (Figure 15). After 6 months the soft tissue gain was reduced and no difference was reported between the initial thickness and after 1 year of observation (Figure 16). Measurement were registered also beyond the mucogingival junction (Figure 17) to evaluate the tissue changes after Guided Bone Regeneration: after 1 year a bucco-lingual reduction of 2.73 mm was observed (Figure 18) 15 mm apical to the free mucosal margin.

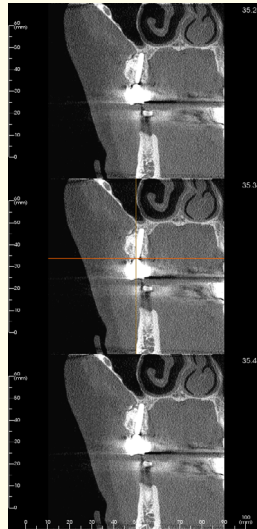


Figure 6: After 1 year from the delivery of the final restorations the CBCT is reporting a dense, thick and well preserved augmented bone.



Figure 7: The lateral view shows the blending of the peri-implant mucosa.

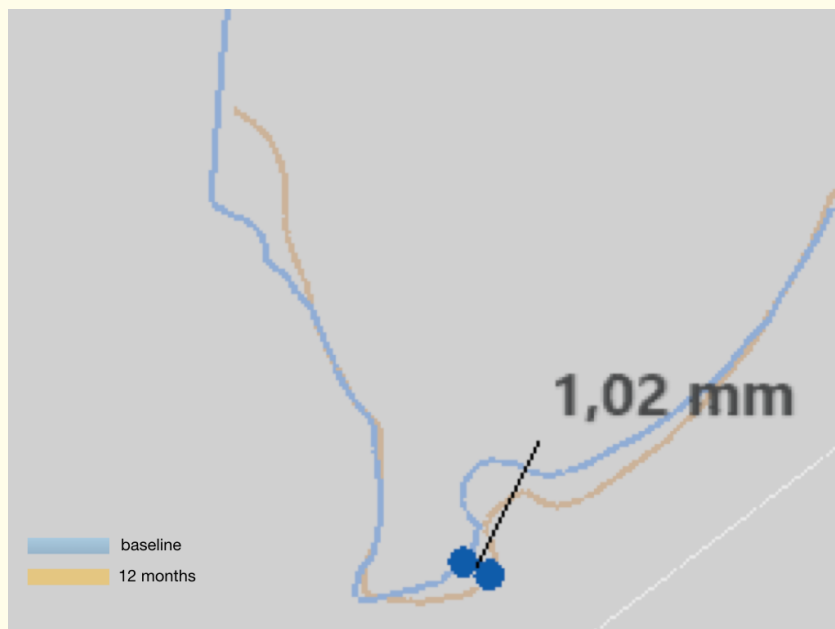


Figure 8: The distal palatal papilla has increased of 1.02mm in thickness and height during a follow up of 12 months from the delivery of the final restoration.



Figure 9: At the distal papilla the col has increased of 1.17mm during a follow up of 12 months.



Figure 10: After 12 months the distal papilla has increased its thickness of 0.68 mm on the buccal aspect but not the height.

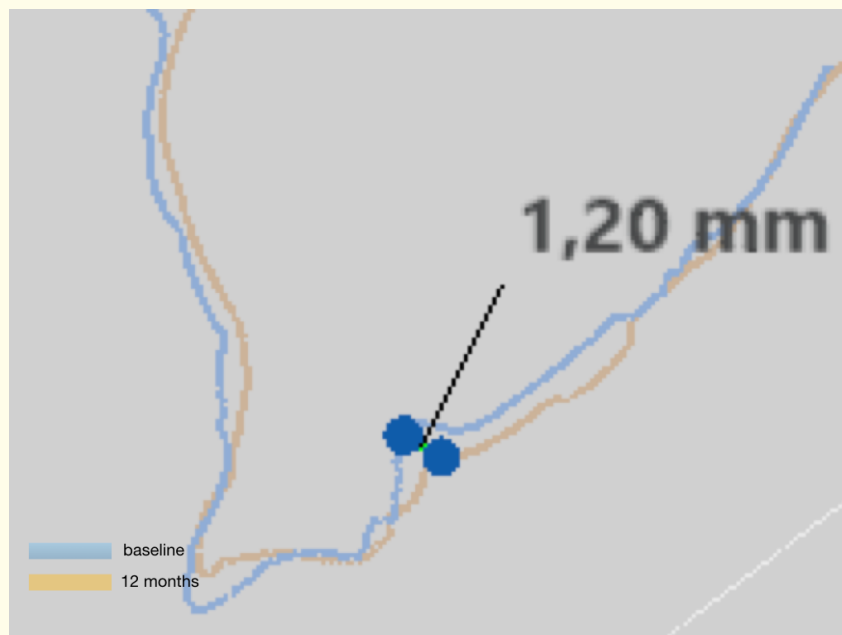


Figure 11: The mesial papilla has increased of 1.2mm on the palatal aspect.

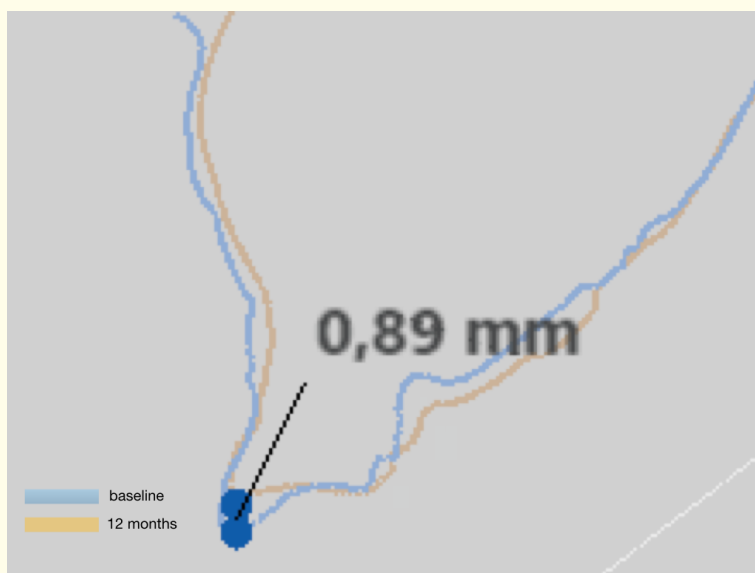


Figure 12: The tip of the mesial papilla has decreased of 0.89 mm after a follow up of 12 months.

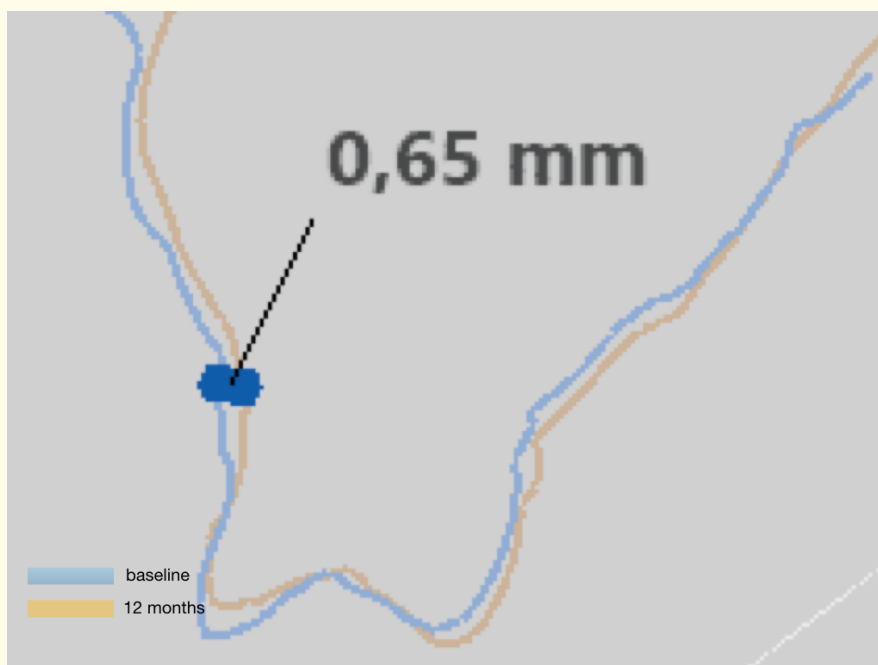


Figure 13: The buccal aspect of the mesial papilla has decreased of 0.65mm during a follow up period of 12 months.

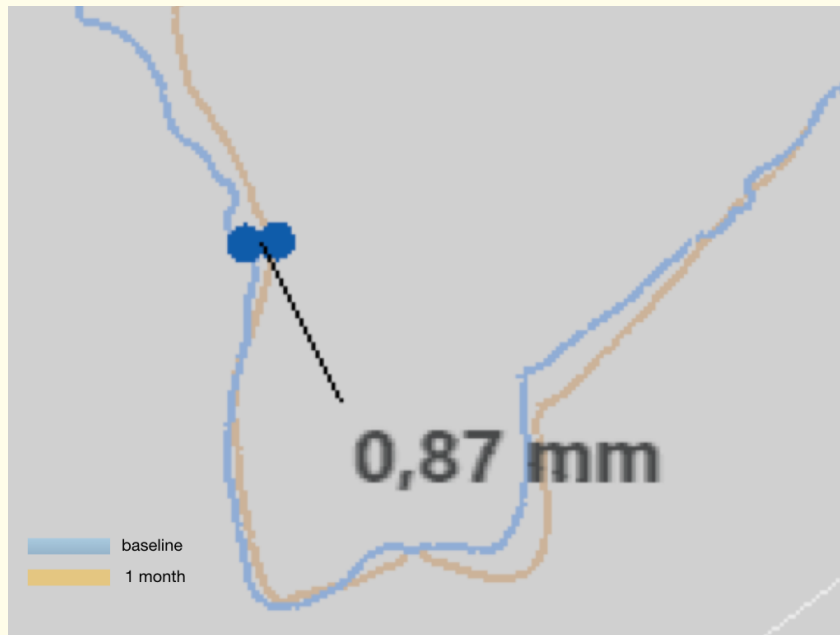


Figure 14: During the first month after the delivery of the final restoration a bucco-lingual collapse of 0.87 mm was registered on the medial aspect.



Figure 15: After 3 months from the delivery of the final restoration a peri-implant soft tissue maturation was observed. The increase of thickness was 0.77 mm compared to the initial level of the soft medial mucosa. A gain of 1.64 mm of buccal soft tissue thickness was achieved in 2 months of tissue maturation.



Figure 16: After 12 months no difference was observed on the medial aspect of the mucosa.



Figure 17: From the tip of the distal papilla and 15 mm apical some soft tissue loss was observed after 1 year.



Figure 18: About 1.5 cm apical to the tip of the distal papilla a bucco-lingual collapse of 2.73 mm was observed.

Discussion

The long-term success rate of dental implants is assured by the implementation of a systematic recall program. Early evaluation of risk factors can be of importance in order to keep the implants in a status of health. The more implants are placed the higher are the chances to face failures or complications.

Among the various application, the medical application of non-contact optical 3D shape measurement have attracted much attention due to its non destructiveness and speed. Optical three-dimensional shape measurements has proven to be useful for several applications. In this article this technology has been utilized not for its original scope but as a non invasive diagnostic tool for monitoring the stability of the peri-implant mucosa as well as the maintenance of the pink esthetics.

The recall check-up appointments are imperative in any patient who have received one or more endosseous implants. Radiological assessment has been considered the gold standard to evaluate the stability of the bone around the implant. However minor changes of the mucosa such as mucositis or recessions may represent the initial stage of an ailing dental implant. Furthermore, these changes cannot be detected by a radiological analysis. Probing depth, bleeding upon probing, suppuration and keratinized tissue have been proposed. However, they seems not to be valuable if not progressive over time and soft tissue monitoring represent then a parameter that needs to be regularly investigate. There is an urgent need then to improve our diagnostic field to improve the maintenance of health and esthetics around dental implants. The main advantage of using a 3D soft tissue mapping is the possibility to monitor the dynamic changes of the peri-implant soft tissues which are critical to prevent esthetic and biological complications.

In the clinical case that was monitored by applying the ultrafast sectioning technique during a follow up period of 12 months changes of soft tissue thickness were recorded mesial, distal and medial to the inserted implant. During the time of observation the distal papilla increased in thickness for more than 1 mm, mainly on the palatal aspect and on the col. However, an increased of papilla thickness was observed also buccal. The mesial papilla also increased in thickness but only on the palatal side. A minor collapse of 0.65 mm was observed on the buccal aspect. This could be related to the presence of a reduced periodontium on tooth #14 that may have reduced the blood flow to the mesial col. On the medial aspect the mucosa was overall stable but major changes up to 1.64 mm were observed. In fact, during the first month the medial soft tissue collapsed and then increased during the following 2 months. After 6 months the tissue thickness reduced but the overall volume was maintained stable. Finally, some soft tissue loss was observed 15 mm apical to the implant where a natural bone remodeling occurred after Guided Bone Regeneration. Clinically this collapse of non keratinized mucosa is not to be considered as significant since the sagittal cuts at 1 year (Figure 6) showed a good thickness of the augmented bone. It is then reasonable to think that the remodeling is occurring at the junction between the augmented bone and the alveolar bone.

Conclusion

Soft tissue mapping by using an ultrafast sectioning technique may be of value as a 3D dynamic monitoring of the peri-implant tissues and pink esthetics. Major soft tissue changes occurred during the first 3 months of soft tissue maturation. Although the clinical and radiographic examination reported no sign of bone loss at 1 year after delivery of the final restoration, the 3D digital soft tissue mapping may be a reliable technique to assess the stability of the achieved pink esthetics.

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