Research article

Soft tissues around an acid-etched healing abutment: a histological and histomorphometrical analysis

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Abstract

Background and objectives. A healthy peri-implant soft tissue has been reported to play a relevant role in the long-term success of a dental implant. The underlying mechanisms of attachment and the factors that affect the integrity of this biological seal are not well understood. The aim of this report was an evaluation of the peri-implant soft tissues around a human submerged acid-etched healing cap.

Materials and Methods. Four implants were inserted in the posterior maxilla. The most distal implant lacked primary stability and, while the other 3 implants were immediately loaded the same day of surgery, it was decided to submerge this implant. An acid-etched healing cap was inserted on this implant to favor the soft tissue attachment. After 6 months, the patient asked, against the advice of the clinicians, to carry out the prosthetic rehabilitation without this implant. The implant, with the surrounding soft tissues was then retrieved after a 6 months healing period.

Results. A tight connection between the soft tissues and the healing abutment was found all around its perimeter. Only in a small portion of the interface a detachment of the tissues was present. Histomorphometry showed a close connection in 97% of the healing abutment perimeter. A close connection was also present at the level of the implant-abutment junction.

Discussion and Conclusion. Roughened surfaces can improve the attachment of the connective tissue to the metal surface. However, further research is required to determine the optimal surface treatment to improve peri-implant soft tissue sealing.

Keywords. Connective tissue, dental implants, epithelium, gingiva.

1. Introduction

A healthy peri-implant soft tissue, with a close contact of the epithelium and of the underlying connective tissue with the implant surface, has been reported to play a relevant role in the long-term success of a dental implant **[1-5]**. These peri-implant tissues are composed of a 2 mm long epithelium and a 1-1.5 mm long connective tissue **[6]**. The underlying mechanisms of attachment and the factors that affect the integrity of this biological seal are not well understood **[2]**.

A promising approach to optimize soft tissue implant integration involves modification of the topography of the implant surface **[7]**. It was hypothesized that

roughened implant surfaces would be effective for soft tissue integration **[7]**. Tissue reactions to implants are determined mainly by surface parameters **[8]**. Implant surfaces with defined characteristics may improve the cell anchoring to the metal surface **[8]**. Cells recognize surface features and react to them, resulting in contact guidance **[9]**. Moreover, the topography of the surface influences the cell adherence and also the cell differentiation, growth and migration **[10]**. The epithelial downgrowth may be stimulated by the disruption of the soft tissue interface induced by micromotion or by cytokines released by cells after stimulation with bacterial-derived products **[11]**. Fibroblasts tend to interdigitate into a rough surface, and to prevent epithelial downgrowth **[7]**.

Most of the histomorphometric studies reported to date in the literature have been done in dogs **[1]**. Human histologic data are valuable to validate and confirm animal models **[4,12]**. Aim of the present report was an evaluation of the peri-implant soft tissues around a human submerged acid-etched healing cap.

2. Materials and Methods

2.1. Clinical procedure

A 59-year-old patient participated in this study. The patient was partially edentulous. Four implants were inserted in the posterior maxilla **(Figure 1A)**. The bone quality of the insertion sites was poor (type 4 bone). The most distal implant lacked primary stability and, while the other 3 implants were immediately loaded the same day of surgery, it was decided to submerge this implant **(Figure 1B)**. An acid-etched healing cap (Dentsply Implants Manufacturing GmbH, Mannheim, Germany) was inserted on this implant to favor the soft tissue attachment. The roughness measure (Ra) of the healing cap was 0.8 μm. After 6 months, the patient asked, against the advice of the clinicians, that to carry out the prosthetic rehabilitation without this implant **(Figure 1C)**. The implant, with the surrounding soft tissues was then retrieved after a 6 months healing period **(Figure 2)**.

2.2. Processing of specimens

The implants and the surrounding tissues were stored immediately in 10% buffered formalin and processed to obtain thin ground sections with the Precise 1 Automated System (Assing, Rome, Italy). The specimens were dehydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). After polymerization, the specimens were sectioned longitudinally along the major axis of the implants with a high-precision diamond disc at about 150 μm and ground down to about 30 μm. Three slides were obtained. The slides were stained with basic fuchsin and toluidine blue.

Histomorphometry of the soft tissues-healing cap contact percentage was carried out using a light microscope (Laborlux S, Leitz, Wetzlar, Germany) connected to a high resolution video camera (3CCD, JVC KY-F55B, JVC, Yokohama, Japan) and interfaced to a monitor and PC (Intel Pentium III 1200 MMX, Intel, Santa Clara, CA, USA). This optical system was associated with a digitizing pad (Matrix Vision GmbH, Oppenweiler, Germany) and a histometry software package with image capturing capabilities (Image-Pro Plus 4.5, Media Cybernetics Inc., Immagini & Computer Snc Milano, Italy). Attachment was determined, according to Kim et al. **[7]**, as the percentage of the implant length in contact with the neighbouring soft tissues.

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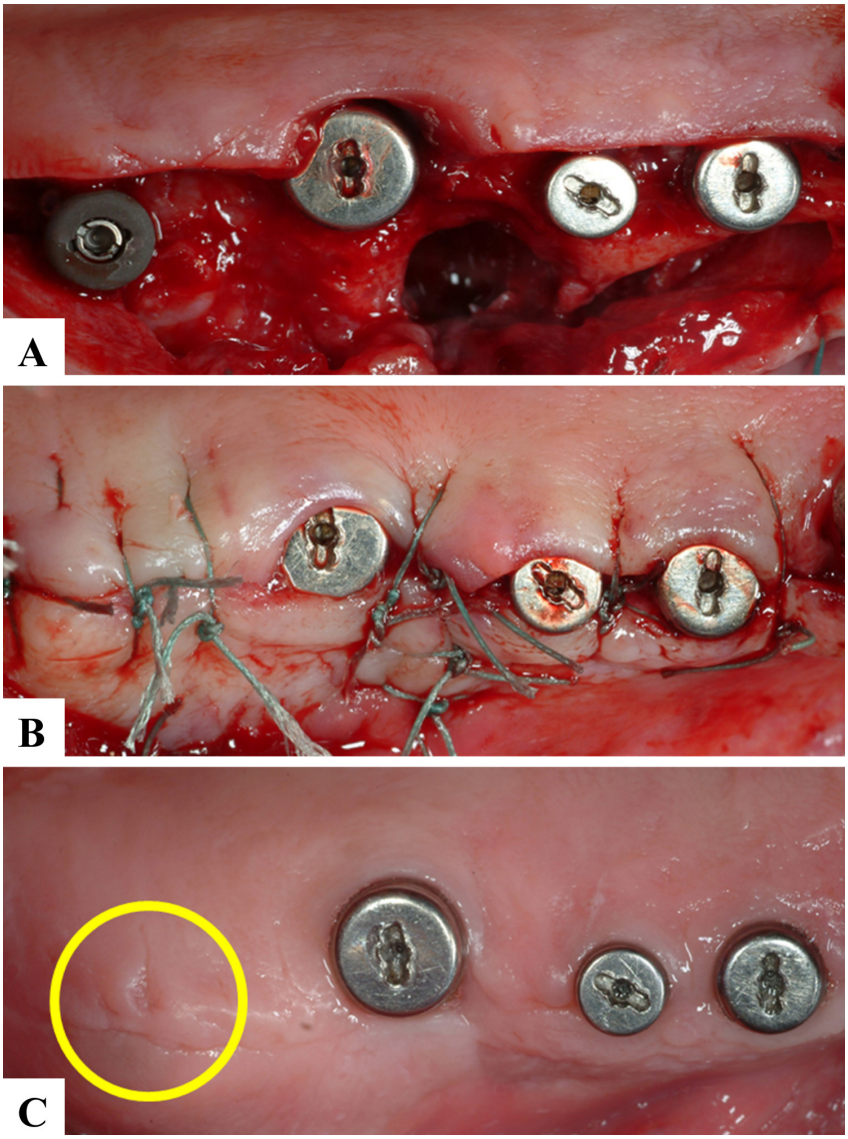

Figure 1. Clinical phases. (A) Four implants were inserted in the posterior maxilla. **(B)** Three implants were immediately loaded the same day of surgery. **(C)** The most distal implant lacked primary stability and it was decided to submerge this implant.

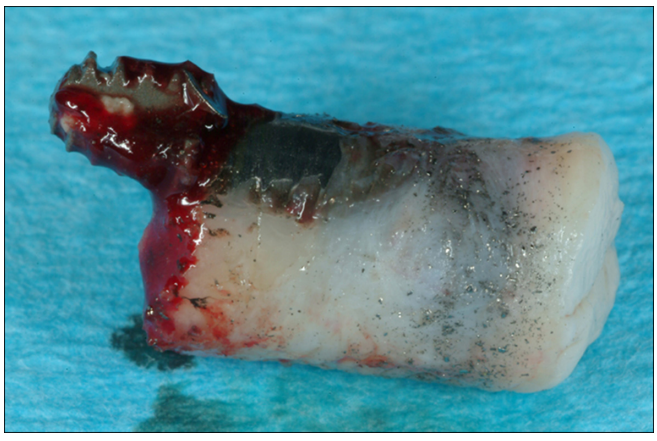

Figure 2. Image showing the retrieved implant with the surrounding soft tissues.

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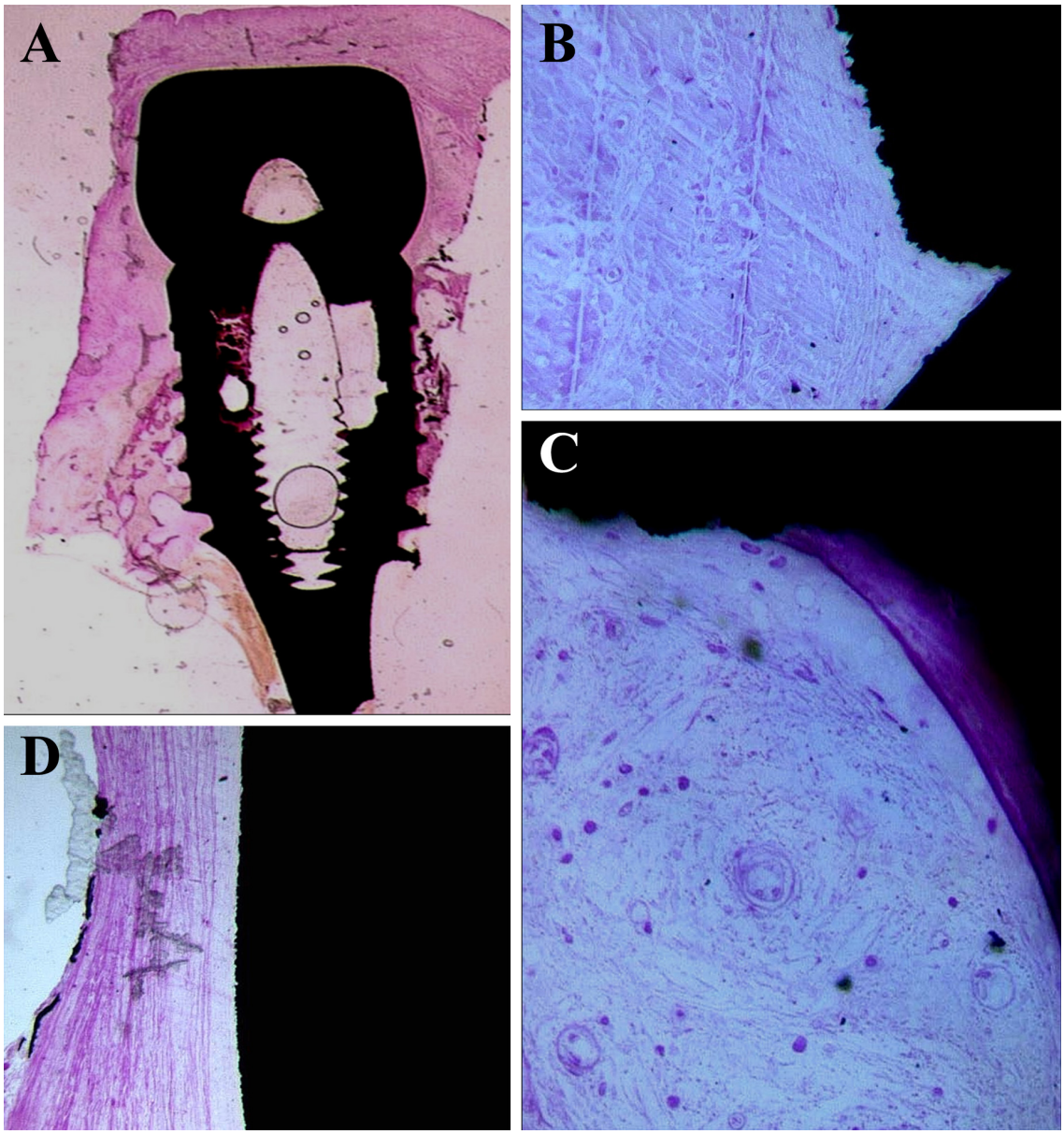

Figure 3. Histological analysis of the sample (staining with Toluidine Blue and Basic Fuchsin). (A) Low power magnification image showing the presence of a dense connective tissue around the healing abutment (magnification 12X). **(B)** Multinucleated giant cells or foreign body reaction cells were not observed (magnification 200X). **(C)** Few, scattered blood vessels were detected (magnification 100X). **(D)** Elongated fibroblasts, with major axis parallel to the long axis of the healing abutment, were seen in contact with the metal surface of the abutment (magnification 200X).

3. Results

At low power magnification, a dense connective tissue was present all around the healing abutment **(Figure 3A)**. At higher magnification, no inflammatory cell infiltrate was present. Multinucleated giant cells or foreign body reaction cells were absent **(Figure 3B)**. Only a few, scattered blood vessels were observed **(Figure 3C)**. Elongated fibroblasts were seen in contact with the metal surface of the abutment; these cells had their major axis parallel to the long axis of the healing abutment **(Figure 3D)**. Near to the abutment surface,

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the tissues presented a denser appearance forming a capsule of 70-150 μm thick. At a distance from the abutment surface, the connective tissue was more loose and more cell-rich. A tight connection between the soft tissues and the healing abutment was found all around its perimeter. Only in a small portion of the interface a detachment of the tissues was present. Histomorphometry showed that a close connection was found in 97% of the healing abutment perimeter. A close connection was also present at the level of the implant-abutment junction.

4. Discussion

A complete understanding of the biology of the peri-implant tissues is still lacking **[3]**. A constant vertical dimension of healthy periodontal tissues is needed to guarantee the esthetics around teeth: this dimension is called Biological Width (BW)**[13]**. The BW is composed by the sulcular epithelium (SE), junctional epithelium (JE) and connective tissue (CT)**[13]**. Around implants the BW represents the dimension of the peri-implant tissues needed to obtain an adequate JE and CT, and to get and maintain a seal around endosseous implants, which provides a protection from mechanical and external biological agents **[13,14]**. The connective tissue shows a close and tight connection to the abutment surface; this connection has been documented to happen through a thin avascular and collagen fiber rich, scar-like tissue of less than 100 μm in width **[4,6,13,15]**. This tissue is surrounded, on the outer side, by an area constituted by connective tissue fibers running in different directions **[6,13,15]**; these fibers appear to be functionally organized **[12]**. Collagen bundles were found to be abundant all around the implant with a maximum density between 200 μm and 800 μm from the abutment surface **[12]**. Collagen fibers were found to be spatially oriented with an inner system dominated by longitudinal fibers and a more external circular system **[12]**. There seems to be a differentiated network of fibers, which might be of clinical relevance as a mechanical protection for the underlying bone **[4]**. In an about 100 to 150 μm wide area adjacent to the implant surface, CT was, in general, free from blood vessels and was dominated by collagen fibers oriented parallel to the longitudinal axis of the implant **[4]**. Adjacent to this area, CT was densely packed with collagen fibers oriented circumferentially around the implant **[4]**. Perpendicularly oriented collagen fibers, directly contacting the implant surface were not observed in any of the sections **[4]**.

While a rough, transmucosal part of an implant will enhance plaque formation, the bony and connective tissue interface requires a porous or microtextured surface to promote tissue ingrowth **[16]**. An increase in the surface roughness of the transmucosal portion will facilitate early plaque formation **[16]**. An ideal transmucosal implant should not only minimize bacterial adhesion, but at the same time allow epithelial and connective tissue abutment **[16]**. Detachment of the peri-implant soft tissues from the implant surface indicates weak tissue attachment **[7]**. The present study showed an almost complete lack of detachment of the soft tissues and this fact, probably, indicates a strong adhesion of the connective tissue **[7]**. In the present case report it was possible to confirm the results of Kim et al. **[7]**, who found in a rat study that, while the coarsely blasted and titanium plasma-spray surfaces showed the highest incidence of complete attachment of the soft tissues, an etched surface produced an integration of the connective tissue that was similar to that observed with much rougher surfaces. It is possible that the unique geometry created by the etching procedure can play a dominant role in promoting the integration of connective tissue **[7]**. Roughened surfaces can then improve the attachment of the connective tissue to the metal surface **[7]**.

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The search for an optimal implant surface able to develop a favorable soft tissue reaction is still ongoing. Even if the literature on the topic is already developed significantly, it is still not possible to draw valid conclusions on the ideal surface for the soft-tissue interface **[17-19]**. The latest approach was to use chemical modifications and nanoroughness to promote this ideal soft tissue attachment and sealing **[20]**, following some patterns that were already discussed for bone integration of dental implant surfaces **[8]**. First results are encouraging **[20]**, but there is still a lack of information on the advantages and disadvantages of the various possible surface modifications, and no consensus on the exact objectives to reach with improved surface treatments.

5. Conclusion

In this report, it was confirmed in this human sample that roughened surfaces can improve the attachment of the connective tissue to the metal surface. This result can be observed in animal studies, but it is still unclear what are exactly the advantages and disadvantages of this kind of surface modifications in human clinical situations. Further research investigations are required to determine the optimal surface treatment to improve peri-implant soft tissue healing and sealing.

Disclosure of interests

The authors have no conflict of interest to report.

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