Histomorphometrical and clinical study of connective tissue around titanium dental implants with porous surface in a canine model

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Statement of Purpose: One of the prerequisites for a successful endosseous dental implant is to obtain a perimucosal seal of the soft tissue to the implant surfaces. Failure to achieve or maintain this seal may result in apical migration of the epithelium into the implant-bone interface and fibrous encapsulation of the root portion of the implant, thus leading to implant loss. The dentogingival collagen fibers around a natural tooth are perpendicularly or obliquely inserted into the cementum and bone, serving as a barrier to prevent epithelium migration, thus enhancing the barrier capability around teeth. However, the connective tissue around dental implants is characterized by collagen fibers that are aligned parallel to the smooth implant surface. In the present study, we made a concave porous structure at the connective tissue and implant surface interface using a laser method, which maintained the uniform cervical portion of the implant. The goal of our work was to test the hypothesis that the special porous topography affects the attachment and alignment of gingival connective tissue fibers to the dental implant after insertion into the mandibular bone of beagle dogs.

Methods: 24 non-submerged commercially pure titanium implants with lengths of 8 mm and a diameter of 3 mm were prepared. The total length of the implant was divided into three zone: 1 mm of the most coronal portion with a machined surface - “epithelial attachment zone” (EAZ), and was adjacent to epithelium tissue; the 5 mm apical portion of the implant with a sandblasted surface - “bone attachment zone” (BAZ), and was placed in the bone; the middle 2 mm between the EAZ and BAZ - “connective tissue attachment zone” (CAZ), and was placed in the gingival connective tissue. The CAZ of the implants was designed with many distributed evenly pores by Nd:YAG laser in order to induce the attachment and in-growth of connective fibers. The three different average diameters of the pores were prepared: 10 μm (group A), 40 μm (group B), 70 μm (group C) and no pores (group D). Two male beagle dogs at least 18 months old were used. Extractions of four mandibular premolars and the first molar were performed bilaterally for each dog. Six implants per quadrant were placed with a random distribution following a three month healing period after the tooth extractions. The sulcus depth around the implants was measured using a Florida Probe. A radiograph was taken from the excised block sections after sacrificing the animals with an overdose of sodium pentothal. An inflammatory cell count, including polymorphonuclear neutrophils and lymphocytes, was made at the connective tissue and epithelium-connective tissue junctions. Every histological image was analyzed with an image analyzer and the length of the implant CAZ was measured. In order to determine the collagen fiber orientation in the gingival connective tissue around the implants, the angles of the fibers attached to the implant surface were measured using polarized light microscopy.

Results / Discussion: Histological sections showed that the gingival tissue was attached tightly to implant surface and there was no significant difference in inflammatory cell invasion or probing depth between groups ($p>0.05$). Histomorphometric analysis demonstrated that no significant difference in total connective tissue length was present among the four groups ($p>0.05$). However, gingival recession in the 40±5μm and 70±5μm porous groups was less than the 10±5μm porous and control groups. Compared with the parallel collagen fibers mainly observed around implant surfaces in the control and 10±5μm porous groups, the collagen fibers mainly oriented obliquely or perpendicular to the implant surface in the sections of 40±5μm and 70±5μm porous groups. The attachment and alignment of collagen fibers seems to be influenced by the surface condition. Also we found that there were collagen fibers inserting into the pores of the 70±5μm implant surface. Fiber insertion observations indicated that pores with relatively larger size could induce collagen fiber insertion and an increased strength of attachment between connective tissue and implant surfaces.

Conclusions: Collagen fibers at the inner zone of connective tissue around 40±5μm and 70±5μm porous implants aligned mostly in an oblique orientation when compared with the mainly parallel fibers direction around the other two groups. It is worthy to note that collagen fibers were inserted into the pores of the 70±5μm porous implant surface, indicating that the pores with a proper size could induce the insertion of connective tissue and prevent gingival recession.

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