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Research paper

Quality of alveolar bone — Structure-dependent material properties and design of a novel measurement technique

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ABSTRACT

The evidence for the efficiency of clinical methods used to assess the quality of alveolar bone in terms of a density measure prior to and during dental implant surgery is limited. The aim of this paper is to describe the biomechanical background which can be used as a basis for determining the bone quality by measuring the elastic properties of the bone and to design a novel device for the determination of the bone quality during dental implant surgery.

Applying material mechanical equations for porous and cellular structured models, the elastic material properties (modulus of elasticity) of cellular and cortical bone as porous structures were approximated over the whole range of relative bone mineral density of trabecular and cortical bone. Based on a circular disc with a central hole reflecting a horizontal cross-section of an implant socket, the mechanical effects of expanding the central hole were studied. Subsequently, the clinical situation of a socket prepared for the placement of a dental implant (depth: 10 mm; diameter 3.5 mm) was simulated using three-dimensional (3D) finite element analysis. A loading device (thickness: 3.5 mm) was placed in the trabecular part of the socket and expanded, while the resulting pressure was recorded and used for the calculation of an elastic modulus. Finite element analysis revealed that it was possible to estimate the bone quality by applying the measurement technique proposed. Maximum deviations of 6% of the experimentally determined elastic modulus from the setpoint elastic modulus were found.

Measuring the internal pressure in a drill hole, e.g., in an implant socket caused by a defined expansion of a rotational symmetric loading device, could be used for establishing a clinically meaningful test system for the objective classification of alveolar bone.

1. Introduction

The quality of alveolar bone is a prognostic factor for the success of implant-supported dental restorations (Norton and Gamble, 2001). As both the type and the architecture of a bone influence its load-bearing capacity (Truhlar et al., 1997; Meredith, 1998), knowledge of the bone quality at the implant site affects both treatment planning and the choice of loading

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