gival location, is the loss of tooth structure at the neck of a tooth. It may be caused mainly by occlusal stress. The association between cervical lesions and occlusal attritions had been studied by some researchers. In the clinical diagnoses, authors observed that the wedge - shaped cervical lesions had different orientations. The lesions point to the coronal (CL), the middle (ML) and the root (RL) of tooth, respectively. In this paper, finite element analyses on how typical occlusal forces affect the orientation of cervical lesion are done, and then numerical predictions are compared with the results of an investigation about occlusal wear regions and orientations of cervical lesions.

Materials and Methods Two finite element (FE) models with same geometric profile as a maxillary premolar with a ML lesion and a mandibular premolar with a RL lesion are established. Referring to the definitions of typical occlusal forces of Zhou et al. (1989), six typical forces for maxillary premolar and three ones for mandibular premolar were applied on occlusal surface of teeth.

One hundred and twenty - four premolars (forty - six maxillary premolars and seventy - eight mandibular ones) were investigated. Both of occlusal wear and cervical lesion were present in these teeth simultaneously. For every tooth, occlusal wear region and orientation of cervical lesion were recorded.

Results Basing on FE results, the relation between typical occlusal forces and types of the produced lesions are given. Typical occlusal forces can be further related with occlusal wear regions. Therefore the types of cervical lesions can be predicted through the observed occlusal wear regions in the investigation. The results of observation and prediction are shown in Fig. 1. It can be found from Fig. 1 that the predictions for the maxillary premolars agree with the observation results by and large. Especially, we predict fifteen teeth with ML correctly and only are four ones given by error. In 44 mandibular premolars with RL, 75 percent are predicted correctly. In addition, FE results show no CL for mandibular premolar. There were 4 mandibular premolars with CL, which occupies 5% of total investigated teeth. That also agrees with prediction. This work, however, only provides a simple explanation for a phenomenon observed clinically, so more effort should be made.

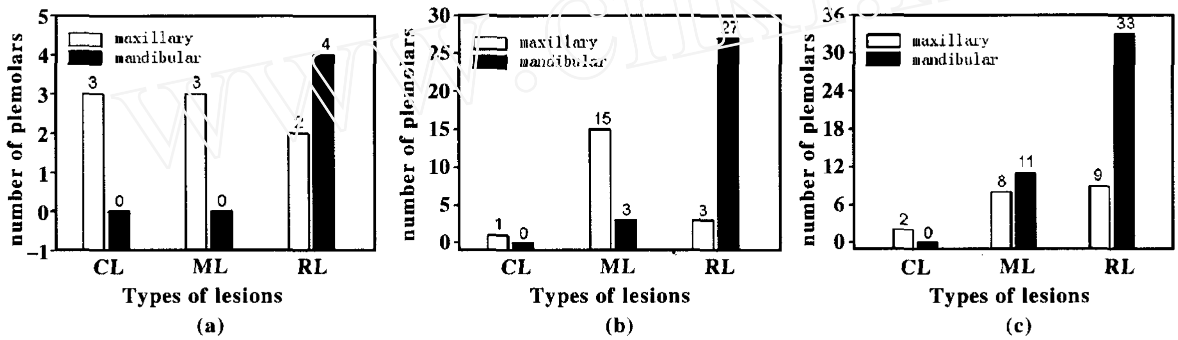

Fig. 1 The predicted orientations of cervical lesions for the observed teeth with (a) CL, (b) ML and (c) RL

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An Inhomogeneous and Anisotropic Constitutive Model of Human Dentin

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Introduction In human dentin, microscopic tubules extend through the entire dentin with variational diameters. The peritubular dentin encircles the tubules and is characterized by its high mineral content. The intertubular dentin occupies the volume outside of peritubular dentin and contains more collagen and less mineral than the peritubular dentin. The above structural characters of dentin should lead to an inhomogeneous and anisotropic stress - strain relation of dentin. In the past years, a lot of experiments based on the microscopic structure of dentin had been done. Some attempts on theoretically modeling constitutive law of dentin were also presented. Here author gives an inhomogeneous and anisotropic constitutive model of human dentin, considering the difference of peri - and intertubular dentin, and compare the FEA results basing on this model with the moiré fringe testing results of Wang and Weiner (1998).

Theoretical Model Assuming that the peri – and intertubular dentin are homogeneous and isotropic material, the corresponding elasticities are denoted by Cp and Ci. The transverse shapes of tubule and peritubular dentin are supposed to be similar and coaxial circles. Adopting some results in the double – inclusion method and so called Two – Phase Model, the overall elasticity of dentin can be given as follows:

$$C^d = C^i\{1 + f_p(S-1)[(C^i - C^{ip})^{-1}C^i - S]^{-1}\}\{1 + f_p S[(C^i - C^{ip})^{-1}C^i - S]^{-1}\}^{-1} \quad (1)$$

where S is the matrix form of Eshelby's tensor, 1 is the unit matrix, C^{ip} is the overall elasticity of the tubule – peritubule composite and f_p is the proportion ratio of this composite to the material surrounded by intertubular dentin.

Finite Element Analysis By means of a moiré fringe technique, Wang and Weiner (1998) presented the displacement distribution in the section (Fig. 1a), which will be referred to Wang – Weiner image in this paper. We established a FE model with the same geometric configuration and boundary conditons as their work. Many investigators ignored the effect of tubules on the mechanical properties of dentin and regard dentin as homogeneous and isotropic, so we will call that the HI Model in this paper. Based on the theoretical model developed in this paper, the variation in mechanical properties within dentin is considered in FE model, which is called IA Model.

When the HI Model was used (Fig. 1b), the distribution pattern reveals a very flat form in most regions of dentin. Only when approaching the pulp cavity, was there a slight curving shape for the isoline due to the effect of the pulp chamber. Based on the IA Model, the FE analysis showed fringe patterns that were similar to Wang – Weiner image. In the dentin near the DEJ, the displacement isolines had a slight turn downwards rather than straight lines as were seen in the HI Models. Within the central part of dentin, the isolines had higher curvature. The above results show that variations in the diameters of dentinal tubules and in the properties of intertubular dentin do indeed contribute to the overall load – bearing properties of teeth. Thus, the IA Model most closely matched the physical properties of dentin shown by Wang – Weiner image.

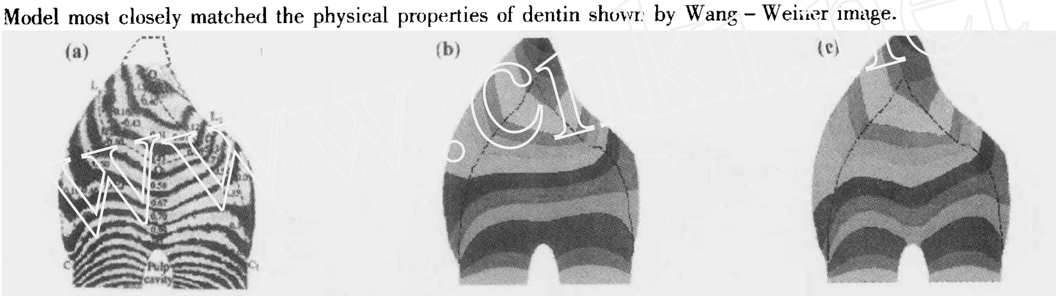

Fig. 1 (a) The fringe figure of the Wang – Weiner image. The isoline images of longitudinal displacement are calculated by (b) HI Model and (c) IA Model of dentin. The dash lines in (b) and (c) describe the DEJ.

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螺旋种植体界面愈合过程的数值模拟

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口腔种植体在植入过程中可产生机械损伤,从而在种植体界面形成由骨基质和血凝块组成的环状坏死区域(本文称为修复区)。在标准的二阶段种植法中,种植体首先埋藏于颌骨内三到六个月(愈合阶段),然后通过第二次手术连接义齿或上部结构,开始承担功能载荷(功能阶段)。因此,种植体在愈合期间并不直接承受载荷,修复区只间接经历由于颌骨在功能载荷作用下的变型所引起的应力。本文的目的在于建立一个关于种植体界面愈合的生物力学模型,并用有限元方法数值模拟种植体界面在愈合阶段和功能阶段的塑建改建过程。

生物力学模型 种植体界面的愈合可以分为两个本质上不同的过程:一是立即开始的纯生物过程,其特征是重建血液供应系统和分泌骨的有机基质;二是有一定延迟的生物力学工程。医学研究表明,在没有外载荷作用下种植体界面的愈合常常是不完全的,外载荷作用对种植体界面的充分愈合起着决定作用。本文拟用数值方法模拟种植体界面愈合的生物力学过程,其基本假定为:(1) 修复区的愈合只能从未受损的骨表面向种植体表面进行,因为医学研究表明,骨的愈合只能在有充分血液供应的条件下进行,而种植体修复区内的微血管重建只能从未受损骨表面开始;(2)