A REVIEW OF THE METHODS OF TOOTH AXIS CALCULATION BASED ON CBCT

Jiaying Liu
School of Computer Science and Technology, Tiangong University, Tianjin, 300387, China.

ABSTRACT

The long axis of a tooth is defined as the geometric axis that passes longitudinally through the tooth and through the center of the tooth, which is one of the most important reference elements for dental analysis and treatment. In the preoperative planning of dental implants, doctors usually examine the axes of adjacent teeth and occlusal axes of missing teeth. When orthognathic surgery is used to treat dental deformities, it is necessary to consider the intersection angle of upper and lower occlusal axes, so as to improve the performance and aesthetics of the masticatory system. However, the traditional method of determining the long axis of teeth depends too much on the experience of doctors, and its efficiency is inefficient and its accuracy is not guaranteed, which often affects the effect of dental treatment. Digital determination of dental long axis technology provides great possibility and convenience to improve the safety of treatment and accelerate postoperative recovery. With the popularity of cone beam computed tomography (CBCT), we can accurately calculate the long axis of teeth through the three-dimensional display of teeth and periodontal tissue. In this paper, the key technologies of tooth long axis calculation are introduced in detail.

KEYWORDS: Long axis of teeth; CBCT; Dental Sciences.

1. INTRODUCTION:

In medical image analysis, it is very important that organs or tissues can be clearly displayed, which is helpful for diagnosis and treatment. The popularity of cone-beam computed tomography (CBCT) provides convenience for dental diagnosis and analysis[1]. CBCT three-dimensional images can provide more information about oral structure, making it possible to better understand and visualize data. Three-dimensional reconstruction of medical images is an important application field of scientific visualization technology, and it is the current research focus of medical image processing. It refers to the technology of using two-dimensional medical slice images to reconstruct three-dimensional images and carry out qualitative and quantitative analysis. Three-dimensional modeling of medical images, which is convenient for observation and analysis from multi-angles and multi-levels, can provide doctors with realistic three-dimensional images. In the field of dental orthodontics and implant, doctors are able to carry out preoperative planning and surgical simulation, so that doctors can know the whole operation process well before the actual operation, and choose the best operation scheme by simulating a variety of operation schemes [2][3]. This is of great significance to improve the success rate of operation and reduce the pain of patients.

For better dental treatment based on accurate dental analysis and diagnosis, the information of the three-dimensional axis of the tooth and the three-dimensional position of the tooth are indispensable. The axis of the tooth, also known as the long axis of the tooth, is a geometric axis that runs vertically through the tooth and through the center of the tooth, or an imaginary line that passes through the center of the tooth. Our teeth are divided into single teeth and multiple teeth. Figure 1. shows the long axis of single-root teeth and multiple-root teeth respectively. The long axis of teeth plays a very important role in the fields of orthodontics and implantology. In dental implants, doctors usually need to examine the axis of adjacent teeth and the occlusal axis of missing teeth before the implantation program. In addition to implants, the dental axis should also be considered when using the virtual surgery planning system [4][5] for dental surgery preparation.

In the treatment of dental deformities, the angle between the upper and lower occlusal axes can be considered to improve the performance and aesthetics of the masticatory system. However, the traditional method of determining the long axis of teeth depends too much on the experience of doctors, and its efficiency is inefficient and its accuracy is not guaranteed, which often affects the effect of dental treatment. Digital determination of dental long axis technology provides great possibility and convenience to improve the safety of treatment and accelerate postoperative recovery. With the popularity of cone beam computed tomography (CBCT), we can accurately calculate the long axis of teeth through the three-dimensional display of teeth and periodontal tissue. In this paper, the key technologies of tooth long axis calculation are introduced in detail.

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In 2019, Kazuto Terada et al. proposed a molar axis estimation method based on CT image. This method no longer extracts the three-dimensional axis of each molar from the segmented volume, but extracts the three-dimensional axis of each molar from two projection images. First, all of the segmented molar data are projected onto two two-dimensional image planes, and then the molar contour is segmented in each two-dimensional projection image. The principal component analysis and the improved symmetry axis detection algorithm are used to extract the two-dimensional axis from the segmented molar contour. Finally, the three-dimensional molar axis is obtained by combining two two-dimensional axes.

At present, restoration-driven surgery is widely used in implant surgery, and the long axis of teeth is very important in implant surgery, which greatly affects the outcome of postoperative restoration. However, there are still many problems to be solved. Tooth segmentation is a complex problem, and the existing methods have their own limitations. This method cannot only avoid the difficulty of tooth segmentation, but also improve the limitations of existing methods. The effectiveness and practicality of this method are verified by the experimental results of different clinical three-dimensional CT images.

The existing methods to calculate the long axis of teeth need to segment the teeth from the CT image, and then estimate the axial direction of the teeth. However, due to the challenge of tooth segmentation in CT images, the existing segmentation methods are not effective, especially for angled molars, which may lead to the failure of axis estimation. In 2016, to solve this problem, Zhang et al. proposed a molar axis estimation method based on CT image. This method no longer extracts the three-dimensional axis of each molar from the segmented volume, but extracts the three-dimensional axis of each molar from two projection images. First, all of the segmented molar data are projected onto two two-dimensional image planes, and then the molar contour is segmented in each two-dimensional projection image. The principal component analysis and the improved symmetry axis detection algorithm are used to extract the two-dimensional axis from the segmented molar contour. Finally, the three-dimensional molar axis is obtained by combining two two-dimensional axes.

In 2019, Kazuto Terada et al. determined the long axis of multiple molars by ordinary least square regression and compared it with the long axis determined by the authors. First of all, the three-dimensional curve is obtained by combining two two-dimensional axes. Usually, experienced dentists can use this technique to correctly calculate the dental axis from three-dimensional CT images, but users who lack the knowledge of anatomy and CT imaging cannot. In addition, this technique requires a lot of fine interaction, so it is difficult to apply it to multiple-root teeth.

In 2016, Li et al. proposed a three-dimensional molar axis estimation method based on CT image, and then estimate the axial direction of the teeth. However, due to the challenge of tooth segmentation in CT images, the existing segmentation methods are not effective, especially for angled molars, which may lead to the failure of axis estimation. In 2016, in order to solve this problem, Zhang et al. proposed a molar axis estimation method based on CT image. This method no longer extracts the three-dimensional axis of each molar from the segmented volume, but extracts the three-dimensional axis of each molar from two projection images. First, all of the segmented molar data are projected onto two two-dimensional image planes, and then the molar contour is segmented in each two-dimensional projection image. The principal component analysis and the improved symmetry axis detection algorithm are used to extract the two-dimensional axis from the segmented molar contour. Finally, the three-dimensional molar axis is obtained by combining two two-dimensional axes.

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