Valuable Radiographic Tool for Odontogenic Jaw Keratocyst Diagnosis and Surgical Planning

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ABSTRACT

Objective: *To investigate the clinical use of cone beam computed tomography in the diagnosis of patients with odontogenic jaw keratocyst and to guide computer-aided surgical treatment planning.*
Methods: *Imaging, image processing, and visualization technologies were used to produce clear diagnosis, provide proper treatment, and formulate favourable prognosis. Cone beam computed tomography was used to collect medical information including site, extent, shape, and other characteristic features of a patient with large odontogenic jaw keratocyst.*
Results: *The imaging technique produced excellent results in imaging, image processing and three-dimensional (3D) visualization.*
Conclusions: *The 3D digital reconstruction model of the odontogenic jaw keratocyst was shown intuitively*.

Keywords: Cone beam computer tomography, image processing, Medical imaging, visualization

Valiosa Herramienta Radiográfica para el Diagnóstico del Queratoquiste Odontogénico Maxilar y la Planificación Quirúrgica

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RESUMEN

Objetivo: *Investigar el uso clínico de tomografía computarizada de rayo cónico en el diagnóstico del queratoquiste maxilar, y guiar la planificación del tratamiento quirúrgico asistido por computadora.*
Métodos: *La imaginología, el procesamiento de imágenes, y tecnologías de visualización, se utilizaron para producir diagnósticos claros, proporcionar tratamiento adecuado, y formular pronósticos favorables. La tomografía computarizada de rayo cónico fue utilizada para recoger información médica incluyendo lugar, extensión, forma y otras características de un paciente con un queratoquiste odontogénico maxilar de gran dimensión.*
Resultados: *La técnica de imaginología produce excelentes resultados en imagen médica, procesamiento de imágenes y visualización tridimensional (3D).*
Conclusión: *El modelo de reconstrucción digital 3D del queratoquiste odontogénico maxilar se mostró intuitivamente.*

Palabras claves: Tomografía computarizada de rayo cónico, procesamiento de imágenes, imágenes médicas, visualización

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INTRODUCTION

Cone beam computed tomography (CBCT) is a medical imaging technique consisting of X-ray computed tomography, where the X-rays are divergent, forming a cone (1). Cone beam computed tomography has become increasingly important in treatment planning and diagnosis in oral maxillofacial surgery. During a CBCT scan, the scanner rotates around the patient's head, obtaining a maximum of 600 distinct images.

The scanning software collects and reconstructs the data, producing a digital volume composed of three-dimensional (3D) voxels of anatomical data. Subsequently,

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the data can be manipulated and visualized using a specialized software (2). A 24-second scan yields an accurate assessment of the patient's bone quality and quantity, as well as a broad understanding of associated anatomical relationships. The radiation dose from a scan is low. This technology, which uses 3D in viewing a patient's anatomy, facilitates accurate and easy perception and diagnosis. This power of perception can also assist in the identification of bone diseases, such as odontogenic jaw keratocyst.

CASE REPORT

A 51-year old male, empirically diagnosed with periapical periodontitis, was referred to our department for accurate diagnosis and treatment. The right mandibular swelling for more than one year did not cause him pain or discomfort. The extent of the buccal bulge was from the right mandibular ramus to the left mandibular premolar region, affecting both the labial and lingual sides. The palpation of the buccal bulge had the same size as a table tennis ball. Antibacterial and anti-inflammatory drug therapy was administered to the patient at a local clinic but the treatment was ineffective. A CBCT scan was performed to gain a 3D anatomical image of the bulge. This CBT imaging system (Kodak 9000C 3D Extraoral Imaging System, USA) produces digital X-ray images including panoramic, cephalometric and volumetric reconstruction modality images. The technical specifications of the imaging system are listed in the Table. The imaging system operates with a Kodak dental imaging software and an acquisition interface module.

Table: Technical specifications of Kodak 9000C 3D Extraoral Imaging System

Components	KODAK 9000C 3D System
Sensor 3D modality technology	Digital volumetric tomography
Sensor technology	CMOS Optical fiber sensor with CsI coating
Tube voltage	60–90kV
Tube current	2–15mA
Frequency	140 kHz (max)
Gray scale	16384-14 bits
Volume size	50 × 37 mm (height × diameter)
Voxel size	76.5 × 76.5 × 76.5 µm
Reconstruction time	Less than two minutes based on the recommended computer system configuration requirements
X-ray pulse time	30 ms
Exposure time	4 to 24 seconds Depending on the patient's type and the programme selection
Programme	12 anatomical settings

The Kodak dental imaging software transformed the multiple volume 3D reconstruction automatically when the radiological image acquisition was finished. The visualization of the 3D reconstruction image was obtained after one to two minutes (Fig. 1).

RESULTS

The 3D reconstruction image of odontogenic jaw keratocyst was acquired using the CBCT scan (Fig. 1), showing the various characteristics of the tumour from multiple directions and multi-angles. The cyst was a multilocular keratocyst; each atrioventricular size was consistent, and the septum existed, the extent of which was from the right mandibular ramus to the left mandibular premolar region. The growth of the septum was along the long axis of the lower jaw and bulging lingually into the cavity defect.

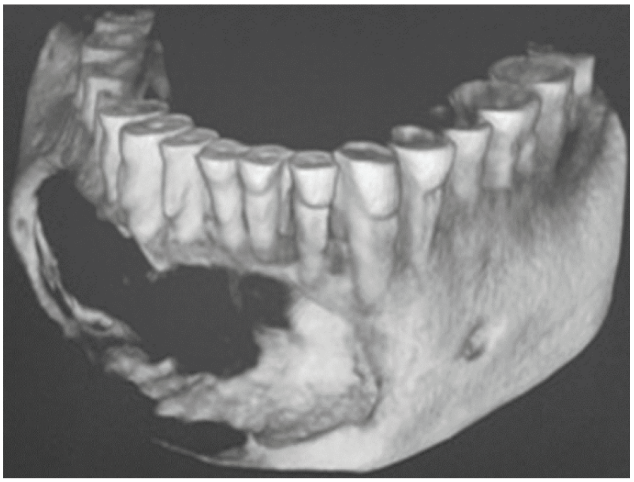

Fig. 1: Three-dimensional reconstruction of odontogenic jaw keratocyst in the right mandibular.

The CBCT scan provided real time adjustments of the radiographic image in sagittal, coronal and transverse sections (Fig. 2). The transverse view showed a multilocular

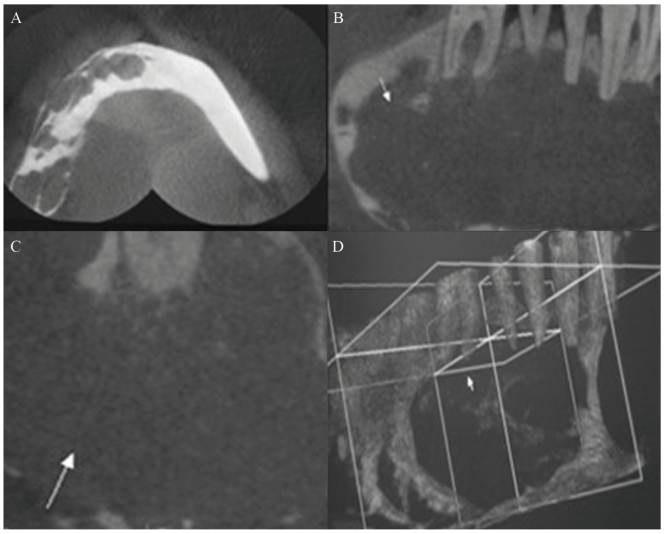

Fig. 2: Radiographic image in three-dimensional (3D) sections. A: transverse section; B: coronal section; C: sagittal section; D: 3D section.

keratocyst, wherein each atrioventricular size was consistent. The septum existed and grew along the long axis of the lower jaw. The coronal view showed the cyst's extent and the number of the remaining bones that surrounded the cyst. Root resorption was likewise shown. The sagittal view revealed that the root resorption, including the resorption position, extent and the scope, could be observed clearly. The 3D section provided a visible image of the position, extent and scope of the cyst. The visible image assisted the doctor in determining the size of the required bone graft.

Based on the radiographic image data, we decided to perform surgery to cut the cyst down and planned a bone graft. The prognosis was good and the patient felt no discomfort.

DISCUSSION

In recent years, the application of CBCT as a non-invasive imaging method in clinical diagnosis and treatment of oral disease has widened. Cone beam computed tomography can use a computer to run the programme in any direction in 3D reconstruction and can obtain the scanning range in any direction and of any level and interval section image. The minimum fault accuracy of CBCT can reach up to 0.076 mm. Thus, oral lesions can be nuanced and stereoscopically observed (2, 3). The traditional spiral CT uses a fan-shaped X-ray beam scanning. The imaging detector is solid and linear and the working principle is based on a continuous spiral movement in the continuous shooting of a series of axial plane imaging and stack imaging. Compared with the traditional fan beam CT, CBCT uses the cone beam scanning, a detector for 2D shape and the pulse transmission multiplanar imaging information in the work process (4). Cone beam computed tomography working mechanism is the 360° rotation scanning through the patient's head. Simultaneously, CBCT acquires volumetric image data of the scan region and uses cone-beam reconstruction algorithm to complete the image of the multiplanar reconstruction. Consequently, a 3D image is formed.

The process improves the scanning velocity, ray utilization efficiency and reconstructed axial resolution. The process has the following additional advantages: low dose on X-ray, not sensitive to motion artefact, fast data acquisition and applicability to dynamic spatial reconstruction. Moreover, the image can be displayed parallel to the direction perpendicular to the dental arch and arch direction, and perpendicular to the direction of the long axis of the body image. Based on the specific needs of clinicians, the image can show the exposure range in any direction and any part of the tomographic images (2, 5).

The clinical manifestation of mandibular keratocyst and other odontogenic jaw cysts is similar. However, keratocyst has the following characteristics: aggressive growth, several local infiltrative growths and, in rare cases, the possibility of cancer (6, 7). In addition, keratocysts have more possibilities for relapse due to the thin and crisp cyst wall, which can be easily broken during operation. Furthermore, completely scraping off the wall is difficult (8, 9). The keratocyst was growing along the long axis of the mandible (Fig. 2). The jaw swelling was not obvious and could be missed easily in clinical examination. Mandibular keratocyst can be observed accurately with the assistance of radiographic imaging and 3D visualization of CBCT scanning.

Mandibular keratocyst operation is different from the general operation of jaw cysts. Mandibular keratocyst is treated by curettage, enucleation, peripheral ostectomy, marsupialization or decompression. However, indications and contraindications exist, and recurrence rate after treatment has been observed (7, 9–12). Treatments are specific to each case according to pre-operative imaging information and patient-specific decision; thus, CBCT can assist clinical surgeons in deciding on surgical treatment and analysis of the prognosis of such treatment (2, 13, 14). A scaling operation requires complete pre-operative diagnosis of odontogenic keratocyst in patients because the keratocyst cystic wall can be easily broken. Therefore, the deep recesses in the inner cystic wall tissue should be carefully scraped. Tincture of iodine (3%) has been used to clean the cautery cavity twice to remove residual cyst wall tissues (9, 15, 16). For multilocular cyst and during recurrence of the disease, the cyst should be cut out in normal bone tissue within the maxillary defect, such as by block resection (9, 14).

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