Development of Microtomography for the Evaluation of Hard Tissue: Reconstruction Image of the Maxillofacial Region of Living Experimental Animal

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Abstract: A novel method of *in vivo* microtomography (micro-CT) was developed. This article reports this system and the evaluation of the maxillofacial region of experimental animal. This system is composed of an X-ray tube, object table and sensor. A living rat under anesthesia was set on the object table. The X-ray tube and sensor were rotated around the object table. The condition was 70 kV and 80 uA. The pixel size was 30 um, isotropic. The field had pixel numbers 512 × 512 × 384. The volume data were visualized by volume rendering. The three-dimensional image depicts the structures of the jaw very clear. The novel micro-CT scanning is useful for observation of bone structures *in vivo*.

Key words: Microtomography, *in vivo*, bone, animal

Introduction

The conventional microtomography (micro-CT) has been used in the research of bone structure. This system is composed of a fixed X-ray tube, sensor and turn-table. The object is set on the turntable. If the system is used for in vivo observation of a living animal, many problems are encountered. The animal may hit the X-ray tube and sensor when the turntable is rotating. Moreover, the radiation time is too long, lasting from a few minutes to several hours. Death of the animal may occur because the radiation dose is very high. In addition, deep anesthesia is required[1].

To solve the above problems of the conventional micro-CT, the author has developed a novel in vivo micro-CT system in collaboration with Rigaku Corporation (Tokyo Japan), and the instrument is named R_mCT[2]. This article reports the novel system and evaluation of the maxillofacial region of an experimental animal.

Material and methods

The new *in vivo* micro-CT has an assembly rotating arm. The X-ray tube and sensor are set on the arm. The object table is set at the center of rotation. This system, called the rotate-rotate system (R-R system), was developed with Rigaku Co. (Tokyo, Japan, Figure 1). A living rat under anesthesia was set on the object table (Figure 2). The radiation time was 17 seconds. The conditions were 80 kV and 70 uA. The field of view was 15mm x15mm12mm . The pixel numbers were 512 × 512 × 384, and the pixel size was 30 um isotropic. After scanning, the image reconstruction time was 2 minutes using a personal computer with i-VIEW (J. Morita Co., Kyoto, Japan). The three-dimensional images were reconstructed by volume rendering.

Results

Figure 3 shows the three-dimensional images the living rat. The teeth and jaw bone structures were depicted very clearly.

Discussion

In 2001, 3-D CT for dental use was developed by J. Morita Co. (Kyoto Japan) with the author's collaboration. This system provides high resolution and requires a low radiation dose of only 1% of the conventional X-ray CT for medical use[3-6]. From 2002, the author started to develop a novel *in vivo* micro-CT system using the technology of Rigaku Co.(Tokyo, Japan). In 2004 September, test run of the new micro-CT was started at the High-tech Center of Matsumoto Dental University.

The novel system has revolutionized research on hard tissue. The conventional system cannot be used to study living animal, because of many problems. For example, the radiation time is too long, the radiation dose is very high, and the anesthesia is very deep. These may result in death of the animal.

The new system solves the above-mentioned problems. The radiation time is only 17 seconds and the radiation dose is very low. The living animal is set on a stable table. The level of anesthesia may be light. There is no loss of experimental animal that is precious for research.

The three-dimensional volume-rendered images are very clear, depicting the teeth and jaw bone structures. Using this system, individual animal can be followed to observe growth and aging, because the animal is not affected by this examination. Serial data are very important for research of trauma and regeneration.

Fig. 1 Overview of new micro CT

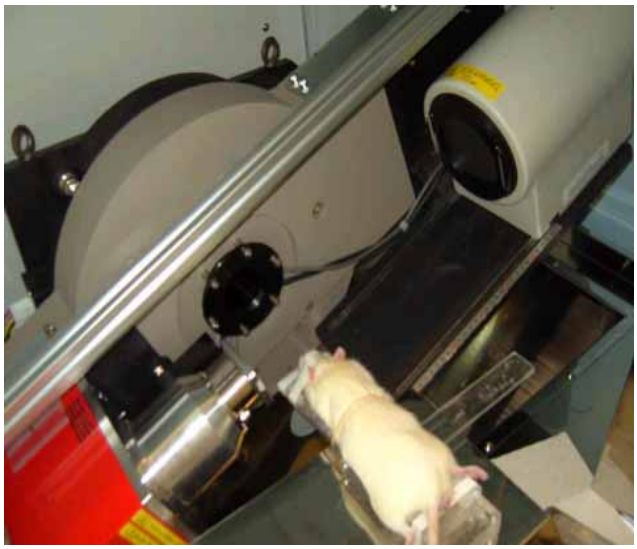

Fig.2 Setting of Animal
The animal set on the stable table under the anesthesia. The X-ray tube and sensor ware rotated around the animal. The radiation time was 17 seconds

Fig.3 Volume rendering image
The image provide three dimensional very clearly.

In the near future, this system will be used widely for *in vivo* research.

Conclusion

The new micro-CT can be used to observe the *in vivo* structures of living experimental animal.

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References

1. Püegsegger P, Koller B, Müller. initial A microtomographic system for the nondestructive evaluation of bone architecture. Calcified Tissue International, 1996;58:24-29.
2. Arai Y, Yamada A, Ninomiya T, Kato T, Masuda Y. Micro-computed tomography newly developed for in vivo small animal imaging. Oral Radiol, 2005,21, 1,14-18
3. Arai Y, Tammisalo E, Honda K, Iwai K, Hashimoto K, Shinoda K. Development of ortho cubic super high resolution CT (Ortho-CT). In: CAR '98 Computer Assisted Radiology and Surgery. Amsterdam: Elsevier; 1998. pp.780-785.
4. Arai Y, Tammisalo E, Honda K, Iwai K, Hashimoto K, Shinoda K. Development of a compact computed tomographic apparatus for dental use. Dentmaxillofacial Radiol, 1999;28:245-248.
5. Terakado M, Hashimoto K, Arai Y, Honda M, Sekiwa T, Stao H. Diagnostic imaging with newly-developed ortho cubic super high resolution CT (Ortho-CT). Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 2000; 89: 509 -578.
6. Ito K, Yoshinuma N, Goke E, Arai Y, Shinoda K. Clinical application of a new compact computed tomography system for evaluating the outcome of regenerative therapy: A case report. J Periodontal, 2001;72:696-702.