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Diagnostic ability of extraoral tuned aperture computed tomography (TACT) for impacted third molars

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Objectives. The purpose of this study was to evaluate the capabilities of a newly developed extraoral TACT system for diagnosing impacted third molars.
Study design. Three dry human mandibles with impacted third molars were used. Nine base images were obtained by the extraoral and intraoral TACT methods. Four board-certified oral and maxillofacial radiologists evaluated TACT slice images as to whether the TACT images could clearly show the periodontal space of the impacted third molar, and the location of the tooth relative to the second molar, or to the mandibular canal. The criteria were excellent, good, fair, poor, and unreadable.
Results. Only the visibility of the periodontal space in extraoral TACT was significantly inferior to that of intraoral TACT. Almost all of the series of TACT images, however, were graded as excellent or good.
Conclusion. The results indicate that extraoral TACT is a useful modality for the clinical assessment of impacted third molars.
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The theory of tomosynthesis was first published by Ziedses Des Plantes in 1938.[1] This theory explains how to synthesize tomographic images for objects at any depth. Because of the difficulty of superimposing film images to generate slice images at an arbitrary position, at that time there were no valuable clinical applications of this method. Developments of computer and digital imaging methods led to a reevaluation of this method in the 1970s.[2-5] Almost all applications of the tomosynthesis theory in this period needed a precise x-ray focus-object-sensor relationship to generate slice images. This made clinical application difficult. Tuned aperture computed tomography (TACT), which was introduced by Webber et al in 1996, does not require a precise focus-object-sensor relationship but a fiducial marker to generate arbitrary slice images.[6,7]

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Many studies have reported on the diagnostic ability of TACT for evaluating such conditions as caries, fractures, impacted teeth, preimplant examinations, and so forth.[8-16] TACT has been conventionally used to obtain basic images using a detector placed in the mouth. In this report, we call this type of TACT method "intraoral TACT." Almost all previous studies were conducted using intraoral TACT. However, when the detector is placed in the mouth, the patient may suffer discomfort caused by the detector. So we developed a new extraoral TACT system to eliminate patient discomfort.

With impacted mandibular third molars, the shape of the root and the relative position to the mandibular canal and the second molar are important diagnostic points that can affect the treatment and prognosis.[17-21] Extraoral TACT, where a sensor is placed outside of the mouth, may be an alternative for the imaging of the mandibular third molar.

The purposes of this study were to evaluate the quality of images obtained using extraoral TACT and to evaluate the capabilities of the system for diagnosing the location of impacted third molars in relation to the second molar and to the mandibular canal. The null hypothesis is that there is no significant difference in the diagnostic ability between intraoral and extraoral TACT.

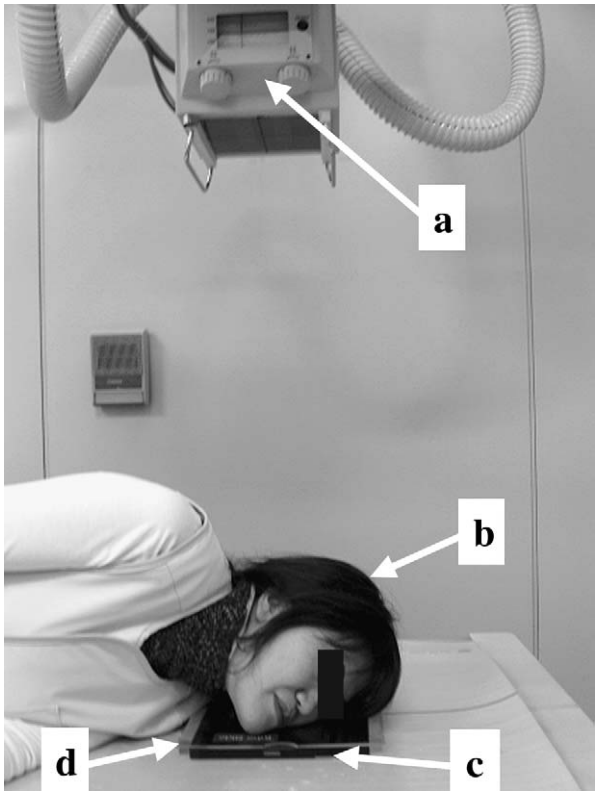

Fig 1. The exposure geometry and components of the extraoral TACT system. **A,** X-ray generator; **B,** patient; **C,** imaging plate cassette; **D,** specially designed cassette folder. Patient lies down in a position where the examination side is place adjacent to the cassette folder. Projection angle can be adjusted easily by the aid of a light beam attached to the x-ray generator.

MATERIALS AND METHODS

TACT systems

The extraoral TACT system consists of an imaging plate (IP) in the form of an extraoral digital sensor (Digora PCT, Soredex, Finland) and an x-ray generator for medical use (Toshiba Medical Systems Corp, Tokyo, Japan). Fig 1 shows the exposure setting of the extraoral TACT system. The cassette (*C*) includes the IP, which is placed under the specially designed cassette holder (*D*) that is attached to the patient table of the x-ray machine. The projection angle can be adjusted easily by the aid of a light beam attached to the x-ray generator (*A*). The intraoral TACT system consists of a dental x-ray generator (HD-70, Asahi Roentgen, Kyoto, Japan) and a size 2 intraoral CCD sensor (CDR2000, Shick Technologies Inc, New York, NY). System specifications and typical exposure parameters of the extraoral TACT and intraoral TACT systems for this study are shown in Table I. The exposure conditions such as tube voltage, tube current, and exposure time were decided by the one of the authors subjectively in a pilot study using a dry mandible phantom.

To assess the physical properties of extraoral TACT, we studied the slice thickness and resolution property of the system. We also studied the clinical feasibility of diagnosing impacted mandibular third molars.

We used TOM-1, which is a specially designed phantom designed for the measurement of tomographic slice thickness and resolution. Fig 2 shows a radiograph of this phantom. This phantom was placed at an angle of 11°32' relative to the tomographic plane, which is parallel to the sensor or film using a positioning jig for TOM-1. On the left half of this phantom, the scale corresponded to the slice depth of the tomograph. On the right half of this phantom, 3 line-pair charts are visible and the resolution of the tomogram can be measured using these line-pair charts.

Nine base images of TOM-1 were obtained by intraoral and extraoral TACT. Exposure parameters for extraoral and intraoral TACT are shown in Table I. TACT slice images were reconstructed using TACT J software (Richard L. Webber, Wake Forest University, Winston-Salem, NC) and slice thickness and resolution properties were evaluated visually by one of the authors.

For the study of the clinical utility of TACT for diagnosing impacted mandibular third molars, 3 dry human mandibles with partially or completely impacted third molars were used. As shown in Fig 1 for extraoral TACT, the cassette containing an imaging plate was positioned as closely as possible to the buccal surface of the mandibular third molar. A lead bead, 1 mm in diameter, was attached to the lingual cortex of the mandible near the region of interest to serve as the required fiducial reference (Fig 3). Two centimeters of soft tissue equivalent material (Toughwater phantom, Kyoto Kagaku, Kyoto, Japan) was placed between the focus and the imaging plate. In this extraoral TACT system, changing the imaging plate for each exposure for base image acquisition caused a small difference in the IP position. To eliminate the influences of these position differences on TACT slice images, 4 reference markers, which were placed on the cassette holder (Fig 1), were used. Using these 4 reference markers allowed the spatial transformation of each base image prior to generation of TACT slices.

For intraoral TACT, the CCD sensor was positioned as closely as possible to the lingual surface of the mandibular third molar using a specially designed sensor holder. A lead bead was attached to the facial cortex of the mandible and a 1-cm Toughwater phantom was used (Fig 4). Nine base images were obtained with the exposure conditions shown in Table I for each TACT method. The projections of the 9 base images included 1 orthogonal and 8 peripheral projections using a circular