Applications of Scanora® Multimodal Maxillofacial Imaging in Orthodontics

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Abstract: *The principles of the Scanora® multimodal radiography system are described. This self-contained unit of X-ray generator, patient chair, and imaging elements incorporates the two basic principles of narrow beam radiography and spiral tomography. Conventional panoramic images or magnified images of the dentition can be produced. In orthodontics, the application of spiral tomography in order to obtain cross sectional images has proved helpful in the assessment of a number of patients. Four cases are reported in which the images obtained using this system has substantially contributed to their management.*

Index Words: Orthodontics, Radiography, Tomography, Unerupted teeth.

Refereed Paper

Introduction

The use of conventional tomography in the maxillofacial regions has largely been limited to assessment of antral, orbital or temporomandibular joint pathology. Many dental radiology departments in the United Kingdom no longer carry out such investigations due to the advent of more advanced cross-sectional imaging such as CT scanning or MRI. However, access to these relatively expensive investigations can be limited for the dentist, and is often difficult to justify the cost and radiation dose when the dentition alone is to be examined. The Scanora® (Soredex, Onon Corporation, Helsinki, Finland) multimodal X-ray unit combines panoramic dental radiography with spiral tomography and its development has renewed interest in the application of tomography to the dental and maxillofacial areas.

The principle of tomography is to visualise a selected image layer within an organ. This is achieved by linking the movement of the X-ray source around an object in the opposite direction from the film, so that the layer at the fulcrum remains in focus. Objects above and below the layer in focus are thus blurred out. The thickness of the layer in focus is determined by the angle of the movement such that the larger the angle of movement, the thinner the layer in focus. The movements involved can be simple linear motions, circular or more complex such as hypocycloidal (Whaites, 1996; Curry *et al.*, 1990). The more complex the movement, the more the tissues outside the focal layer are blurred out and thus the likelihood of artifacts is reduced. The Scanora® system utilises a spiral movement (Fig. 1).

Imaging Principles of the Scanora® System

The Scanora® system consists of an X-ray generator with a rotating anode, a patient chair and imaging elements. The control panel displays the kilovoltage (kV), milliamperage (mA), patient size, exposure time(s), and the imaging programme (Tammisalo *et al.*, 1992). The machine allows all these parameters to influence each other. In other words, patient size selection or change in kV will influence the mAs, and the imaging programme selected, influences the kV and mAs. Patient positioning is the same for practically all examinations performed and is very straight forward using a light beam diaphragm system. The Scanora® utilizes the two basic imaging principles of narrow beam radiography or spiral tomography.

Scanning Narrow Beam Radiography

The standard panoramic image (DPT) with which we are familiar is produced by rotational scanning beam radiography. The magnification factor for this programme using the Scanora® is on average 1:1·3 which is similar to other panoramic machines. Panoramic images centring on the mid-face can also be achieved, and can be used for the assessment of fractures or the examination of the maxillary sinuses. A dental programme produces a similar image to the conventional panoramic, but at a greater

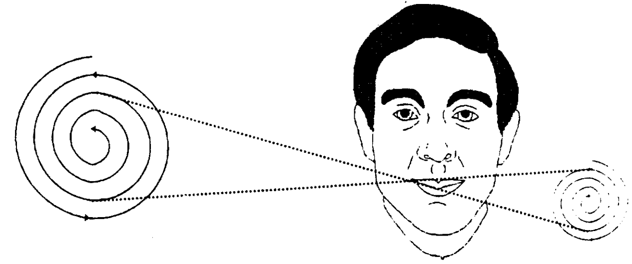

FIG. 1 Diagram demonstrataing the principle of spiral tomography. The X-ray source and film move in a spiral, in opposite directions, the fulcrum is the area of interest.

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magnification of, an average 1:1·7 and is largely limited to the dentition. The images achieved using the Scanora® dental programme have been reported to have significantly better subjective image quality than the standard Scanora® panoramic images (DPT) or that from other panoramic machines (Molander *et al.*, 1995). The linear scanning narrow beam radiography programme can produce detailed images of a variety of areas as stereoscopic pairs which can be read in both horizontal and vertical directions. These images have been found to have comparable diagnostic potential to periapical examinations (Tammisalo *et al.*, 1994).

Spiral Multidirectional Tomography

The second imaging principle used is spiral multidirectional tomography using either a wide angle (layer thickness of 2 or 4 mm) or small angle (layer thickness of 8 mm). The cuts achieved can be tangential to the arch, progressing from labial to lingual or can be cross-sectional, progressing from mesial to distal. Tangential cuts are useful for assessing periodontal bone loss and periapical lesions (Hallikainen *et al.*, 1992). Cross-sectional cuts are useful for assessing the shape of the alveolar ridge prior to the placement of implants and to assess the position of the mandibular canal. The temporomandibular joints can be imaged using either narrow beam radiography or tomography. The dose to the patient obviously depends on the investigation undertaken, but appears to be similar to a conventional panoramic radiograph (Frederiksen *et al.*, 1994).

Practical Application

Two methods are recommended for identifying the area to be examined. The first is to obtain a panoramic image of the patient on the Scanora® and mount this on a horizontally scaled viewing box supplied by the manufacturer (Fig. 2). This is used as a 'scout' view and by moving a vertical indicator to the area of interest, the coordinates for selection of the most appropriate programme can be established. The second technique utilizes a study cast of the patients teeth. The most appropriate match is made to a series of dental arches depicted in the manufacturers manual. Co-ordinates are then identified and the programme selected. This obviates the need for an initial panoramic image and minimises exposure to the patient. Occasionally, with sufficient experience, and for examinations of the incisor regions, it is possible to select the appropriate programmes directly.

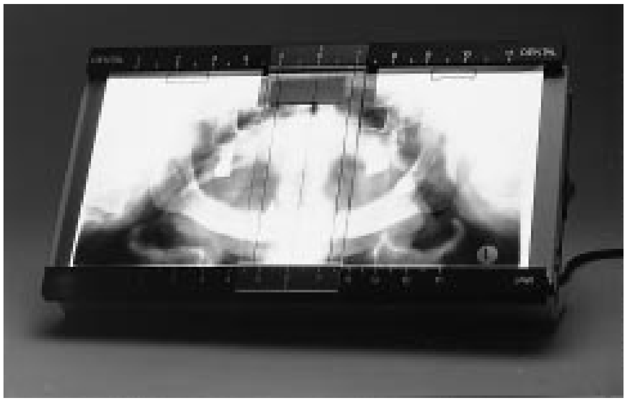


FIG. 2 Light box with radiograph demostrating localization of co-ordinates for programme.

Clinical Applications

Four cases are illustrated which demonstrate some typical situations where spiral tomography has been particularly useful in case assessment and treatment planning. Scanora® radiographs are usually clearer than the illustrations represented here because some of the definition of the radiographs is lost in the photographic processing.

Case 1

A 9-year-old girl was referred to the Orthodontic Department because of failure of eruption of the upper left central incisor. There was a history of trauma at the age of 5 years when the patient fell over and knocked her upper deciduous incisors. On examination she had a Class II division 1 malocclusion in the mixed dentition. The upper left central incisor was unerupted and short of space. An intra-oral occlusal radiograph suggested that the tooth was dilacerated although the extent of this was not clear due to the superimposition of the roots of adjacent teeth and it was also felt that there would be too much superimposition using a lateral cephalogram. A panoramic and cross sectional tomograph (4 mm cut) were obtained (Fig. 3a,b) which showed the true extent of the dilaceration with a moderate degree of root distortion. It was felt that this tooth could be accommodated in the arch and, therefore, a course of orthodontic treatment was initiated to bring it down into position.

Case 2

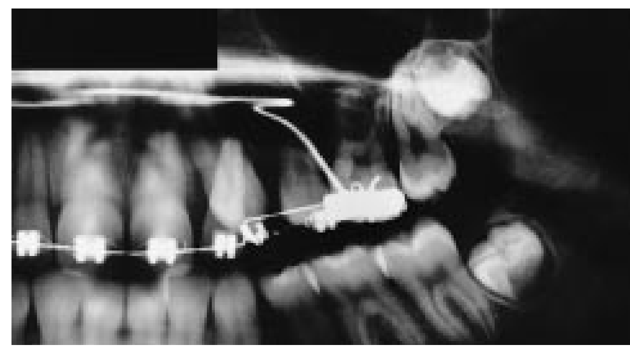
A 14-year-old girl was referred to the Orthodontic department because of failure of eruption of the upper left permanent canine. Clinical and radiographic examination indicated that the tooth was palatally positioned (Fig. 4a). Orthodontic treatment was instigated. All four first premolars were extracted, the canine surgically exposed and an upper fixed appliance fitted. As the canine was being aligned, the root of the lateral incisor became more and more buccally displaced, and the patient complained of pressure and discomfort from the area. There was a bulge in the buccal sulcus adjacent to this tooth, and it was felt appropriate to remove the bracket on the lateral incisor and continue traction to the canine. However, the bulge in the buccal sulcus became more noticeable as treatment progressed and a Scanora® examination was undertaken to determine precisely the position of the roots of the canine and lateral incisor. As shown in Fig. 4b,c, the palatally positioned canine had pushed the lateral incisor almost through the alveolar buccal plate. Although, even under high intensity illumination, the Scanora® tomograph (4 mm cut) suggested a complete absence of buccal bone labial to the upper lateral incisor, it is still possible that a very thin layer remained which may have been burnt out on the radiograph. Traction was immediately stopped to the canine

(a)

(b)

FIG. 3 (a) Panoramic radiograph showing the unerupted upper left central icisor. (b) Cross-sectional tomograph showing the horizontal inclination of the crown and the upward dilaceration of the root of the left central incisor.

(a)



(b)

(c)

FIG. 4 (a) Part of the pretreatment panoramic radiograph (Cranex) showing the palatally impacted upper left canine with its crown overlying the root of the upper left central incisor. (b) Part of the Scanora® (dentition only) view showing the crown and root of the canine overlying the lateral incisor. (c) Cross-sectional tomograph showing the marked buccal displacement of the lateral incisor due to the palatal canine. There was virtually no bony buccal covering seen with high illumination.

for a period of 6 weeks. Further orthodontic treatment was restarted using a sectional appliance to the upper canine only and this tooth was successfully aligned after a further 5 months of treatment. The upper left lateral incisor root moved spontaneously in a palatal direction and the patient has not experienced any further problems with this tooth. In view of this, further radiographic examination was not considered justifiable.

Case 3

An 8-year-old girl was referred to the Department of Paediatric Dentistry because of failure of eruption of the upper left central incisor. An intra-oral anterior oblique occlusal radiograph suggested dilaceration of this unerupted tooth. Because the degree of dilaceration could not be assessed, Scanora® examination consisting of a panoramic radiograph and cross sectional tomographs (4-mm cuts) was undertaken (Fig. 5a, 5b). The degree of malformation of the crown of the upper left central incisor had not been fully appreciated on the occlusal view (in contrast to case I) and was deemed to be beyond saving. Therefore, this tooth was extracted and the patient provided with a temporary partial upper removable denture. At a later stage, consideration will be given to transplanting a lower premolar into the upper central incisor site.

Case 4

A 16-year-old male patient was referred to the Department of Orthodontics for a routine assessment. It was noted that the patient had a retained lower right deciduous canine and a standard panoramic radiograph indicated that the permanent canine was lying horizontal with the crown facing distally in the mandible (Fig. 6a). In addition, a small supernummery tooth was noted adjacent to the root of the lower right first premolar. A surgical opinion was obtained and it was decided to leave the unerupted canine and supernummery in situ due to the possibility of damage to the roots of the erupted teeth and inferior alveolar nerve if surgical removal was attempted. The patient was kept under review and was seen one year later when a further panoramic radiograph was taken (Fig. 6b). This showed the canine was migrating further distally. It was considered that the canine might damage the roots of the erupted molars and a surgical opinion was again obtained. Because of the proximity to the roots of the molars and the inferior alveolar nerve, Scanora® cross-sectional tomography (4 mm cuts) was carried out to ascertain the precise bucco-lingual position of the canine (Fig. 6c). The canine is clearly seen to be in a buccal position clear of both the molar roots and the inferior alveolar canal. The tooth was subsequently extracted under general anaesthesia. There were no post-operative complications and as the patient declined further orthodontic treatment, he was discharged to the care of his General Dental Practitioner.

Conclusions

The Scanora® system was developed initially with a view to the management of implants. However, more and more instances have been found for its application. Its use in the assessment of impacted teeth, for example, their angulation, any adverse curvature of the root, and their effects on other teeth, such as root resorption, has been significant. It is a prerequisite in radiation protection that every radiographic exposure must be justified, such that, the management of the patient is likely to be

(a)

(b)

FIG. 5 (a) Scanora® panoramic view showing a very high unerupted left central incisor. (b) Cross-sectional tomograph showing the malformed upper left central incisor.

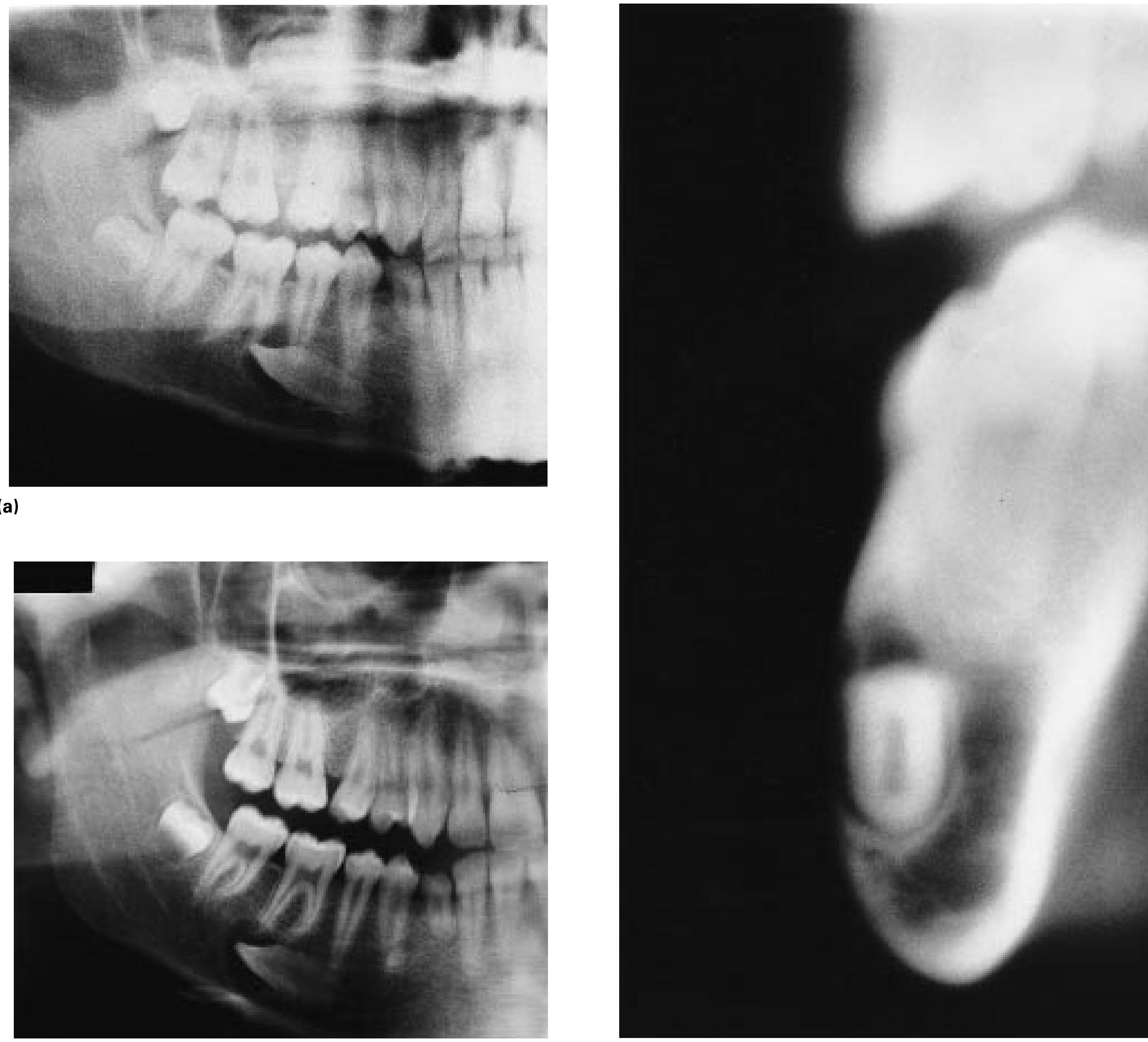


FIG. 6 (a) Panoramic view showing a horizontally impacted lower right canine, the tip of the crown is adjacent to the mesial root of the first molar. There is also a small supernummery adjacent to the mesial root surface of the first premolar. (b) Panoramic view showing the distal migration of the canine, the tip of the crown is now distal to the distal apex of the first molar. The supernummery has also moved inferiorly. (c) Cross-sectional tomograph showing the buccal position of the canine relative to the roots of the molar.

altered or the prognosis changed. It was felt that these criteria were satisfied in all the cases described. The dose implications to the patient are variable, and obviously depend on the number and thickness of the cuts, the area irradiated, and the kV and mAs. Stochastic risk (non-threshold such as genetic effects) resulting from exposure in tomography, has been calculated to be similar to that for standard panoramic images (Frederiksen *et al.*, 1994). The dose for tomography of individual implant sites has been found to be less than that for CT (Kassebaum *et al.*, 1992). However, the need to have a Scanora® panoramic image in order to locate the correct programme for further examination when the patient may already have a satisfactory diagnostic image from a different machine does necessitate a further exposure. In all our cases we felt that this small increase in exposure could be justified by the outcome. With increasing experience and usage of the system, we are selecting a Scanora® panoramic view as the initial examination in patients who are likely to require cross sectional tomography in the future. Therefore, we would envisage that the number of additional exposures will be substantially reduced.

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