THE DETAILED EVALUATION OF SUPERNUMERARY TEETH WITH THE AID OF CONE BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

The aim of this paper is to demonstrate the application of a recently developed three-dimensional imaging system, cone beam computed tomography, in the detailed evaluation of supernumerary teeth.

Two-hundred and twenty three patients with supernumerary teeth (68 females and 155 males) were included in this study. Patients ranged in age from 12 to 25 years. Supernumerary teeth were detected by clinical examination and traditional radiographies. Moreover, careful investigation for more details was made with the cone beam computed tomography. Supernumerary teeth which were detected with the examinations of the cone beam computed tomography images were classified according to the number, location, shape and eruption rate.

The prevalence of supernumerary teeth was determined to be 1.45% of the study population. Males were affected more than females in a ratio of 2.3:1. Supernumerary teeth were most frequently located in 86.2% of the cases in the maxilla; 10.1% in the mandible and 3.7% both in the maxilla and mandible. Supernumerary teeth were most commonly conical in shape (68.8%). One supernumerary tooth was present in 67.7% of the patients, 30.9% had two, and 1.4% had three supernumeraries.

Definite and early diagnosis of the supernumerary teeth is very important. Detailed examinations and evaluations of these teeth with three-dimensional images is very beneficial in terms of treatment planning and preventing complications which may occur.

Keywords: tooth abnormality, supernumerary teeth, cone beam computed tomography

Introduction

Recently, tooth abnormalities have become an important point in dentistry. Care should be taken in order to determine the tooth abnormalities. There are varying abnormalities, therefore, they are classified according to their number, size, shape and structure (10, 13).

Teeth in excess of the normal number are referred to as “supernumerary teeth.” Supernumerary teeth, also called hyperdontia, are included in number abnormalities. The majority of supernumerary teeth are considered to develop as a result of horizontal proliferation or a hyperactivity of the permanent or deciduous dental lamina (25). Moreover, heredity is believed to be an important aetiological factor in the occurrence of supernumerary teeth. Many published cases of supernumerary teeth mentioned recurrence within the same family (31, 47). Also, many authors suggested inheritance as a key factor in the development of supernumerary teeth (9, 16, 47, 49). Cadenat et al. (9) pointed out the presence of a recessive gene on an autosome and a gene on the inhibiting X chromosome. Most are isolated events, although some may be familial and others may be syndrome associated (Gardner syndrome and cleidocranial dysplasia) (4).

Supernumerary teeth may be classified according to location and morphology (8, 17, 34). Locational variations include mesiodens, paramolars, distomolars and parapremolars. Variations in shape consist of conical types, tuberculate types, supplemental teeth and odontomas. Supernumerary teeth may, therefore, vary from a simple odontoma, through a conical or tuberculate tooth to a supplemental tooth which closely resembles a normal tooth. Also, the site and number of supernumeraries can greatly vary (44).

Traditional radiographic examinations are usually limited to two-dimensional (2-D) images that are captured using radiographic film or digital sensors. Crucially, essential information of the three-dimensional (3-D) anatomy of the tooth/teeth and adjacent structures is obscured, and even with the best intentions and paralleling techniques, distortion and superimposition of dental structures in periapical views are unavoidable (12, 24). Recently, a series of cone beam computed tomography (CBCT) scans dedicated to the imaging of dentomaxillofacial structures have been developed (12, 46, 53, 55). A major advantage of cone beam computed tomography
that has been reported is the 3-D geometric accuracy compared with traditional radiographs (37). Sagittal, coronal and axial CBCT images eliminate the superimposition of anatomical structures.

Use of cone beam computed tomography has been useful for the diagnosis of fractures (36, 56) and periapical lesions (21) and in endodontic surgery (42) and implant planning (2). However, few studies have addressed the diagnosis and evaluation of supernumerary teeth with the aid of cone beam computed tomography (26).

The aim of this paper is to describe the potential applications of CBCT technology concerning supernumerary teeth and to evaluate the characteristics of using cone beam computed tomography. Moreover, this study has been carried out to show detected supernumerary teeth in study populations in terms of prevalence, location, shape anomaly and eruption rate.

Materials and Methods

Patients
In the present study, 15357 patients were examined and the study sample comprised 223 patients (155 males and 68 females) ranging in age from 12 to 25 years with diagnosed supernumerary teeth in different regions of the dental arches. Reasons for attendance included caries, malocclusion, lack of eruption of permanent teeth and routine dental checkups. All patients with supernumerary teeth in this study attended the Paediatric Dentistry and Orthodontics Departments at the Dicle University Faculty of Dentistry between January 2009 and March 2010 for detailed evaluation of the supernumerary teeth using CBCT (i-CAT®, Model 17-19, Imaging Sciences International, Hatfield, Pa USA). All subjects were given verbal and written information concerning the study and after entering the study, signed a written consent form regarding all verbal and written information concerning the study. All procedures in this experiment were performed according to the ethical principles established by the Declaration of Helsinki.

Radiographic examination
The diagnosis of one or more supernumerary teeth was made from periapical, occlusal, or panoramic radiographs. In addition, cone beam computed tomography was used for more detailed evaluation of the patients with supernumerary teeth. All clinical and CBCT imaging data were collected from the patients’ records in the computer database of the CBCT machine. None of the patients who entered in this study suffered from syndromes known to predispose to supernumerary teeth. The CBCT device (i-CAT®, Model 17-19, Imaging Sciences International, Hatfield, Pa USA) consists of a standard high-frequency fixed anode X-ray tube (120 kVP, 3–7 mA) and 19.2 x 23.8 cm amorphous silicone (a-Si) flat panel image detector, and uses a cone-shaped x-ray collimator with a 15-degree aperture centered on an x-ray area detector. It acquires its raw data with a single 360° rotation in 8.9 seconds around the patient’s head, with a projection at every 1° step, captured by an amorphous silicone flat panel image detector and stored on a hard drive. The x-ray emission time was 3.5 seconds. Exposures were made with 5.0 mA, 120 kV and an exposure time of 4 seconds. A reconstruction time of ~30 seconds was applied. All images were obtained with 440 projections, the voxel dimension in the reconstructed image was 0.3 X 0.3 X 0.3 mm and the reconstruction shape was cylindrical.

As the 3-D images were being examined, the following records were evaluated in all patients: gender, distribution according to jaws and locations, and the shape, number, and position (eruption rate) of the supernumerary teeth. Each supernumerary tooth was classified according to location (Mesiodens, Parapremolar, Paramolar and Distomolar) and shape (Conical, Tuberculate, Supplemental and Odontoma).

Statistical analysis
All results were analyzed using the Statistical Package for Social Sciences (SPSS) software, version 15.0 and the Medcalc version 9.4.2.0. Data analysis included descriptive statistics (frequency distribution and cross-tabulation). Chi-square and Fisher’s exact tests were used to determine the statistical significance for an association between the occurrence of supernumerary teeth and the distribution on the jaws, gender, the prevalence, locations, relationship between eruption rate and shape. The level of significance was set at P<0.05.

Results and Discussion
In this study, 15357 patients, with a mean age of 14.57±2.22 (14.30±1.92 for males, 14.81±2.44 for females) with an age interval of 12 to 25 years, were observed in order to determine the presence, gender, location and relationship between eruption rate and shape of supernumerary teeth. The number of male and female patients were 7211 (46.96%) and 8146 (53.04%), respectively (Table 1).

Prevalence and distributions of supernumerary teeth in the study population by gender (n=15357)

<table>
<thead>
<tr>
<th>Gender</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Males</td>
<td>155</td>
<td>1.01</td>
<td>7056</td>
<td>45.95</td>
</tr>
<tr>
<td>Females</td>
<td>68</td>
<td>0.44</td>
<td>8078</td>
<td>52.60</td>
</tr>
<tr>
<td>Total</td>
<td>223</td>
<td>1.45</td>
<td>15134</td>
<td>98.55</td>
</tr>
</tbody>
</table>

*X2=46.202

The prevalence of supernumerary teeth was determined to be 1.45% of the study population (p<0.0001). Supernumerary teeth were observed in 155 males (1.01%) and 68 females (0.44%) and the difference with respect to gender was statistically significant (p=0.000, X2=46.202, Table 1). Of 223 patients with supernumerary teeth, 155 (69.5%) were males and 68 (30.5%) were females; the sex ratio was 2.3:1. There was a total of 298 supernumerary teeth with an average of
1.34 per person, of which 208 were found in males and 90 in females.

Most frequently, supernumerary teeth were determined in the maxilla (n=257, 86.2% of the supernumerary teeth) and the mandible (n=30, 10.1% of the supernumerary teeth) and both in the maxilla and mandible (n=11, 3.7% of the supernumerary teeth) (Fig. 1). According to gender, the difference with respect to jaws was not statistically significant (p>0.05, X²= 6.076).

A total of 119 patients (67.7%) had one supernumerary tooth, 69 (30.9%) had two supernumeraries, and the remaining 3 (1.4%) had three supernumeraries. The distribution of supernumerary teeth by gender and number, and relationship between eruption rate and shape of supernumerary teeth is given in Table 3. 74 supernumerary teeth (25.1%) were erupted and 221 (74.9%) impacted; odontomas were omitted from the analysis. The impacted supernumerary teeth included 163 conical shaped, 45 tuberculate shaped and 13 supplemental teeth. Of the 205 conical-shaped supernumerary teeth, 20.5% were erupted, and 53.6% of the 15 supplemental teeth were erupted; the difference in rate of eruption between these two types being statistically significant (p=0.0003, X²=12.865, Table 3).

Supernumerary teeth may have a normal morphology or may be rudimentary and miniature. Also, supernumerary teeth may be erupted or impacted. Some cases of impacted supernumeraries are asymptomatic and are only detected during radiological examinations (40, 59). Radiographs are helpful in evaluating the location, position and nature of these anomalies.

Distribution of supernumerary teeth by gender and number (n=223), and relationship between eruption rate and shape of supernumerary tooth (Odontomas excluded)

<table>
<thead>
<tr>
<th>Shape of Supernumerary Tooth</th>
<th>Conical</th>
<th>Tuberculate</th>
<th>Supplemental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>103</td>
<td>51</td>
<td>1</td>
</tr>
<tr>
<td>Females</td>
<td>48</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>151</td>
<td>138</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 3
Supernumerary teeth may occur in both dentitions, but they are more frequently seen in the permanent dentition (25). The reported prevalence of supernumerary teeth in the general Caucasian population for the permanent dentition ranges from 0.1 to 3.8% (8, 33, 41, 49, 57). In this study, the prevalence of supernumerary teeth was 1.45%. Methodology for detection and the studied population could account for the cited range of prevalence.

Sexual dimorphism is reported by most authors (1, 25, 30, 40, 51) with males being more commonly affected. Rajab and Hamdan (40) reported a 2.2:1 ratio of sex distribution while Luten (30) found a sex distribution of 1.3:1. In a study conducted by Zilberman et al. (58), the sex ratio was 2.5:1, again favouring males. A study of supernumerary teeth in Asian school children found a greater male to female distribution of 5.5:1 for Japanese, and 6.5:1 for Hong Kong children (48). Yusof (57) stated a 9:2 male-female ratio in the occurrence of supernumerary teeth while Liu (27) reported a 3:1 ratio. In this study, the sex ratio was 2.3:1 in favour of males, a value that falls between the sex ratios reported for Caucasian populations (8, 20, 34, 41) and that reported in Israel (59). The difference in sex ratio may be due to racial differences or possible sampling differences.

Supernumerary teeth may occur singly, multiply, unilaterally or bilaterally in the maxilla, mandible or both (40). It has been reported that supernumerary teeth occur more frequently in the maxilla (90%) than in the mandible (10%) (18). Regarding the location of diagnosed supernumerary teeth in our study, we found a larger proportion of supernumerary teeth in the maxilla than in the mandible (Fig. 1), in agreement with other studies (18, 26, 38, 39, 40).

The most frequent locations of supernumerary teeth are the anterior maxilla and the mandibular premolar regions in permanent dentition (35, 38). Bodin et al. (6), reported that the most common locations of supernumerary teeth are between maxillary central incisors, then mandibular premolar, maxillary molar, mandibular incisor, maxillary premolar and mandibular molar region. These results are in agreement with our study’s data for location of supernumerary teeth (Fig. 2).

Their development might precipitate a variety of complications such as crowding, delayed eruption or displacement of adjacent teeth, periodontal disease, increased
incidence of dental caries in adjacent teeth, diastema development, cystic lesions and resorption of adjacent teeth, malformation of adjacent teeth such as dilaceration, and loss of vitality of adjacent teeth (4, 20, 54). Therefore, early diagnosis, proper evaluation and appropriate treatment are essential (4).

Supernumeraries appear in a variety of shapes, the most common in the present study being the conical type- 68.8% (205 teeth), followed by tuberculate type 20.8% (62 teeth), then by supplemental teeth 9.4% (28 teeth) and odontoma 1% (3 teeth). Rajab and Hamdan (40) reported 74.8% conical, 11.9% tuberculate, 6.9% supplemental, and 6.4% odontoma among the study population. Our results were in agreement with Rajab and Hamdan. It is well established that supernumerary teeth are more frequently single tooth (14, 27, 32, 40, 50, 59), while multiple supernumerary teeth appear frequently as two teeth (14, 27, 40, 50, 59). In our study, 67.7% had one supernumerary tooth, 30.9% had 2 supernumeraries and 1.4% had 3 supernumeraries. This result is in agreement with the other studies (26, 40, 59).

Supernumerary teeth may develop in the direction of normal eruption, appear inverted, transverse, assume an ectopic position, or follow an abnormal path of eruption. Besides, supernumerary teeth could erupt normally or remain impacted. It has been found that approximately 25% of permanent supernumerary teeth are erupted, and the remainder are unerupted (33, 59). In contrast, Tay et al. (50) recorded a lower rate, of approximately 15%, of permanent supernumeraries erupted and Liu (27) reported a higher rate, of 34%. In the present study, 24.9% of the supernumerary teeth were erupted, which is similar to other reported eruption rates (33, 59). Liu (27) showed that supplemental teeth had a higher frequency of eruption. Our study also showed that although supplemental teeth may erupt, a significantly higher proportion of the conical-shaped teeth had erupted (p=0.0003). The high rate of impaction can be explained by the later formation of supernumerary teeth in comparison to normal teeth (18). Because the majority of supernumerary teeth are impacted, radiographic diagnosis is of great importance.

The ability to accurately locate supernumerary teeth and determine their relationship with adjacent teeth and other anatomical structures in the area is often a necessity in clinical dentistry, especially when extraction of supernumerary teeth or ectopically impacted teeth or orthodontic intervention is indicated. To minimize harm to adjacent tooth roots and trauma to surrounding tissue, determining the best surgical approach is of utmost importance (5).

Radiographic examination is an essential component of the management of dental problems. Periapical, occlusal, and panoramic radiographs are usually able to provide the required information, however these modalities do not always provide sufficient information concerning the 3-D relationship between supernumerary or ectopically impacted teeth and structures for surgical planning (24). As a result, more advanced imaging techniques can, on occasion, be required.

In recent years, a new method, cone beam computed tomography (CBCT) has been introduced specifically for dental applications (3). In CBCT, a series of 2-D image data sets can be integrated mathematically to produce cross-sections in any plane or 3-D images (52). Projections begin from the anteroposterior position, and data from these digital images are then used in the algorithm of volumetric tomographic reconstruction. The selected plane for primary reconstruction is aligned parallel to the occlusal plane. The acquired set of axial images is reconstructed into bi-dimensional sections (transaxial views and panoramic views) or 3-D representations. The transaxial views are images of sections perpendicular to the axial plane, and the panoramic views are images of sections perpendicular to the axial planes, calculated along parabolic arches located by users at the dental arch. The 3-D images are generated and optimized after selecting the region of interest and adjusting the angle and grey level (26).

CBCT produces 3-D information on the facial skeleton and teeth, also it is increasingly being used in many of the dental specialities, including orthodontics, orthognathic surgery, trauma and implantology (11, 19, 22, 58). Moreover, CBCT is able to clearly show the intraosseous location, inclination, and morphology of impacted or supernumerary teeth, as well as their distances from adjacent roots, teeth, and the cortical bone (24). In addition the use of CBCT technology in dento-maxillofacial imaging, it provides a number of potential advantages compared with computed tomography such as X-ray beam collimation to the area of interest, reduced effective dose and less artifacts (29, 43).

In general, the lower the voxel size and the longer the scan time, the better the resolution and details are; however, a smaller voxel size and longer scan time creates a larger data set so the reconstruction time is longer. Also, these protocols are more sensitive to patient movement, so it is critical to restrict patient movement during the scan. Longer scan times also delivers a higher radiation dose. In our study, standard scans have been used which were taken at Full 13cm, 8.9 seconds and 0.3 voxel. This captures the entire maxillofacial region from above the condyles down to below the lower jaw, at the most practical scan time (reducing chance of movement), at a reduced radiation dose, with a voxel size that maximizes detail without the dataset being too large. Therefore, it is recommended to use a faster scan time for children and some elderly patients. In this way the radiation dose is the lowest, and there is less opportunity for movement of the patient.

The effective radiation depends on the settings used (kVp and mA). The use of lower mA and/or collimation are some of the ways to reduce the amount of radiation, but at the same time the image quality may suffer. The doses from CBCT are significantly lower than conventional CT, yet are higher than doses from the traditional views used in dentistry (28, 29, 45, 46). Exposure dose from a CBCT machine has been reported to be as low as 45 μSv (micro-sievert, SI unit for ionizing radiation) to as high as 650 μSv (28). Exposure from a full-mouth series of analog radiographs has been reported to be
150 μSv (15), and 54 μSv for an analog panoramic radiograph (23). As a comparison, a roundtrip airplane flight from Paris to Tokyo exposes passengers to an effective dose of 139 μSv (7). The radiation dose emitted in our study was similar to that from three to four intraoral radiographs.

In treatment approach, supernumerary teeth's shape, position and its potential effect on adjacent teeth should be taken into consideration. Therefore, compared to 2-D images, in this study which was performed using CBCT we had the chance of more detailed examinations and evaluations of supernumerary teeth. It was aimed to prevent the possibility of complications and to eliminate symptoms by choosing the extractions of supernumerary tooth/teeth. Following the necessary surgical procedures of the patient who applied to our dental faculty with such complaints as crowding and missing teeth, they were taken to orthodontic treatment. A total of 61 (82.4%) erupted supernumerary teeth were extracted due to orthodontic, periodontal and aesthetic reasons and incidence of caries. As much as 185 (82.6%) of 224 impacted supernumerary teeth were surgically extracted due to resorption of adjacent teeth, infection, delayed eruption and maleruption of adjacent teeth. The other 13 erupted and 39 impacted supernumerary teeth were symptomless and also the patients were not willing to have their teeth extracted. Therefore, they were only informed about their presence and follow-up was recommended.

Conclusions

The advantages of the CBCT system, a summary of its applications, working procedures and radiation doses are discussed. CBCT scans tend to result in a more objective and therefore more accurate determination of the supernumerary teeth. However, compared to conventional approaches their uses should be justified before they are used. Thus, before carrying out investigation, the necessity of CBCT and risk/advantage analysis need to be determined.

The CBCT system provides considerably more information for oral diagnostic purposes. According to our results, CBCT can offer useful information for diagnosis, detailed evaluation of supernumerary teeth and treatment planning that conventional radiographs are unable to provide.

REFERENCES


