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Research Article

Application of Cone-Beam Computed Tomography (CBCT) in diagnosis and evaluation of Supernumerary Teeth

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ABSTRACT

Background and Objectives: The aim of this paper is to describe the application of a newly developed three-dimensional imaging system, Cone-Beam Computed Tomography in the diagnosis and evaluation of supernumerary teeth.

Material and Methods: One hundred and eighty-five patients with supernumerary teeth (134 males and 51 females) were included in this study. Patients ranged in age from 6 to 38 years. Supernumerary teeth were detected by clinical examination and conventional radiographs. 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 analyzed according to the number, location, shape and position.

Results: Males were affected more than females in a ratio of 2.6:1. 95 % supernumerary teeth were located in maxilla and 5 % in the mandible. 71.6% of supernumerary teeth were conical in shape. 93.6% supernumerary teeth were impacted and 6.4% were erupted. A total of 198 supernumerary teeth were found to be present in palatal/lingual side and 24 were found on the buccal side. 80.5 % of the patients had one, 18.9 % had two, and 0.5 % had three supernumeraries.

Conclusion: Detailed examinations and evaluations of these teeth with Cone-Beam Computed tomography (CBCT) yields accurate 3-dimensional pictures of supernumerary teeth, local dental and bony structures which are very beneficial in terms of proper diagnosis and treatment planning and preventing complications which may occur.

Key Words: Cone-Beam Computed Tomography, Diagnosis, Odontoma, Supernumerary teeth

INTRODUCTION

Teeth in excess of the normal number are referred to as supernumerary teeth, also called hyperdontia. The reported prevalence of supernumerary teeth ranges between 0.3-0.8 % in primary dentition and 0.1-3.8 % in

the permanent dentition [1,2]. Supernumerary teeth are most common in permanent dentition than the primary dentition and are most frequently found in maxilla than the mandible. Although several theories have been suggested about the cause of supernumerary teeth, 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 [1, 7]. Moreover, heredity is believed to be an important etiological factor in the occurrence of supernumerary teeth. Many published cases of supernumerary teeth mentioned recurrence within the same family [5, 6]. Also, many authors suggested inheritance as a key factor in the development of supernumerary teeth [6, 7]. Multiple supernumerary teeth are usually associated with syndromes like cleidocranial dysplasia and Gardener syndrome and conditions such as cleft lip, palate or both.

Supernumerary teeth may be classified according to location and morphology [8, 9]. The 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 [10].

Imaging is an important diagnostic adjunct to the clinical assessment of the dental patient. Both intraoral and extraoral procedures (periapical, occlusal, paralleling techniques, orthopantomographs), used individually or in combination, suffer from the same inherent limitations of all planar two dimensional (2D) projections - magnification, distortion, superimposition and misrepresentation of structures. The introduction of cone beam computed tomography (CBCT) specifically dedicated to imaging the maxillofacial region heralds a true paradigm shift. The unprecedented interest in CBCT from all fields of dentistry is because it has created a revolution in maxillofacial imaging - facilitating the transition of dental imaging from 2D to 3D images and expanding the role of imaging from diagnosis to surgical procedures. A major advantage of CBCT that has been reported is the 3-D geometric accuracy compared to that of conventional radiographs [11].

The aim of this paper is to describe the potential applications of CBCT technology in detailed evaluation of the supernumerary teeth for diagnosis and its management. This study has also been carried out to show detected supernumerary teeth in study populations in terms of prevalence, gender, location, shape anomaly and eruption (impacted/erupted).

MATERIAL AND METHODS

Patients

A total of 890 patients were included who have been referred in the in-patient department of oral and maxillofacial surgery at the Hebei Medical University, School of Stomatology, between July 2011 to February 2013. The study sample comprised 185 patients (134 males and 51 females) ranging in age from 6 years to 38 years with diagnosed cases of supernumerary teeth in different regions of the dental arches and the mean age of the patients comprised in the study sample was 9.72. This study sample

includes only those patients which were referred to the in-patient department of oral and maxillofacial surgery, Hebei Medical University School of Stomatology for detailed evaluation of the supernumerary teeth using CBCT. No patients who have been included in this study sample suffered from syndromes known to predispose to supernumerary teeth. The study protocol was approved by the ethics committee of Hebei Medical University, School of Stomatology and the all procedures in this study were performed according to the ethical principles established by the Declaration of Helsinki.

Radiographic examination

The periapical, occlusal, or panoramic radiographs were used to diagnose one or more supernumerary teeth. In addition, cone beam computed tomography was used for further detailed examination of the patients with supernumerary teeth. The clinical and CBCT imaging data of the patients were collected from the patient's records in the computer database of the CBCT device.

The CBCT device: KAVO 3D Exam, Model 17-19, Imaging Sciences International, Hatfield, Pa USA (Fig. 1) was used which consists of a standard high frequency anode X-ray tube (120 kVp, 3-7mA) and 16.5 x 13.5 cm amorphous silicon (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 a raw data with a single 360^{o} rotation in 8.9 seconds around the patient's head, with a projection at every 1^{o} step. The images are captured by an amorphous silicone flat panel image detector and stored on a hard drive. The x-ray emission time was 8.9 seconds. Exposures were made with 5.0 mA, 120 kVp and an exposure time of 8.9 seconds. Major reconstruction time of ≤ 2 minutes and real-time minor reconstruction time were applied. All the images were obtained with 440 projections. The voxel dimension in the reconstructed image was 0.3 x 0.3 x 0.3mm and the reconstruction shape was cylindrical.

The CBCT imaging data were collected from the patients and the images were then examined. The following records were evaluated in all patients: gender, number, distribution according to jaws and locations, the shape, and the position (erupted or impacted) of the supernumerary teeth. The supernumerary teeth were analyzed according to location as mesiodens, parapremolar, paramolar, and distomolar, and according to the shape as conical, tuberculate, supplemental, and odontome. The statistical analysis was done by Microsoft office Exel 2007.

RESULTS

In this study, a total of 890 patients were examined, of which, 185 patients were diagnosed presenting one or more supernumerary teeth and included in this study sample. The study samples were observed with the aid of CBCT in order to determine the number, presence, location, position (impacted / erupted) and the shape of the supernumerary teeth (Fig. 3-15).

1. Of 185 patients with supernumerary teeth, 134 (72.4%) were males and 51 (27.6%) were females. The sex ratio determined was 2.6: 1.
2. There were a total of 222 supernumerary teeth with an average of 1.2 supernumerary teeth per person. 160 (72%) supernumerary teeth were found in males and 62 (28%) in females.

3. The supernumerary teeth were most frequently found in maxilla (n=211, 95% of the supernumerary teeth) and the mandible (n=11, 5% of the supernumerary teeth), but no supernumerary teeth were found in both maxilla and mandible in this study sample. In males, 158 supernumeraries were found in the maxilla and 2 in the mandible, whereas in females, 53 supernumerary teeth were found in the maxilla and 9 in the mandible (Fig.2).
4. A total of 149 patients (80.5%) had 1 supernumerary tooth, 35 patients (18.9%) had 2 supernumerary teeth, and the remaining 1 patient (0.5%) had 3 supernumerary teeth.
5. 204 supernumerary teeth (93.6%) were impacted and 14 (6.4%) were erupted; odontomas (Fig. 9) were not included in the analysis.
6. A total of 198 supernumerary teeth were found to be present in palatal/lingual side and 24 were found on the buccal side.
7. According to the locational variations, the anterior maxilla was the most frequent site for supernumerary teeth. The majority of supernumerary teeth found in this study were the mesiodens (n=207, 93.6% of the supernumerary teeth), followed by the parapremolars (n=8, 3.6% of the supernumerary teeth). A total of 7 supernumerary teeth were not classified according to the locational variations due to an ectopic position or an abnormal path of occurrence and were not included. According to the gender, no significant differences were found with the occurrence of mesiodens, but of 8 parapremolars, 6 parapremolars were found in females and 2 parapremolars in males. All 8 parapremolars were found in the mandible.
8. According to the variations in shape of supernumerary teeth, most commonly found supernumeraries were conical in shape (71.6%), followed by tuberculate (22.5%), then by supplemental (4.1%) and odontoma (1.8%). The supernumerary teeth determined according to shape anomaly are listed in Table 1.

Table 1. Shape of the Supernumerary Teeth

Shape anomaly	Males	Females	Numbers	%
Conical (Peg Shape)	117	42	159	71.6%
Tuberculate	39	11	50	22.5 %
Supplemental	2	7	9	4.1 %
Odontoma	2	2	4	1.8 %
Total	160	62	222	100 %

Total patients with supernumerary teeth: 185
Total number of supernumerary teeth: 222

Fig. 1: KAVO 3D Exam, Model 17-19, Imaging Sciences International, Hatfield, Pa USA

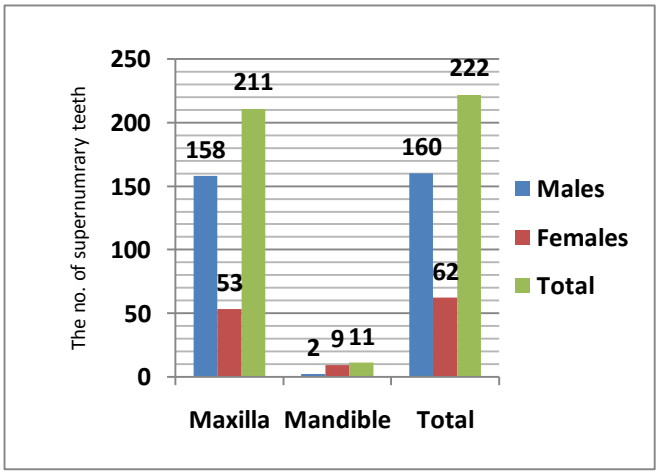

Fig. 2 The distribution of supernumerary teeth according to the gender and jaws

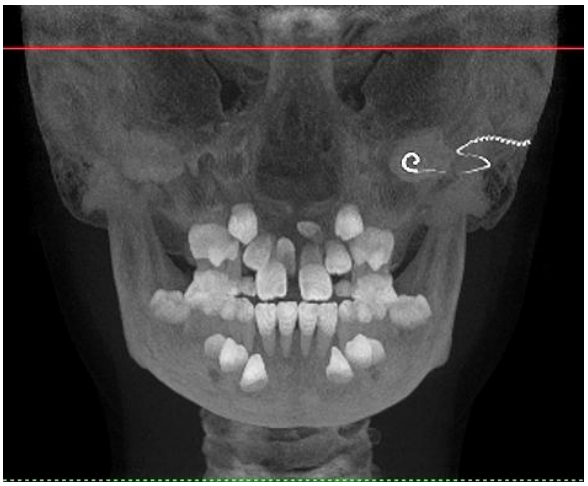

Fig. 3 The frontal tomograph shows two inverted tuberculate supernumerary teeth located in the anterior maxilla

Fig. 4 The sagittal section of CBCT shows an inverted turberculate supernumerary tooth in the palate

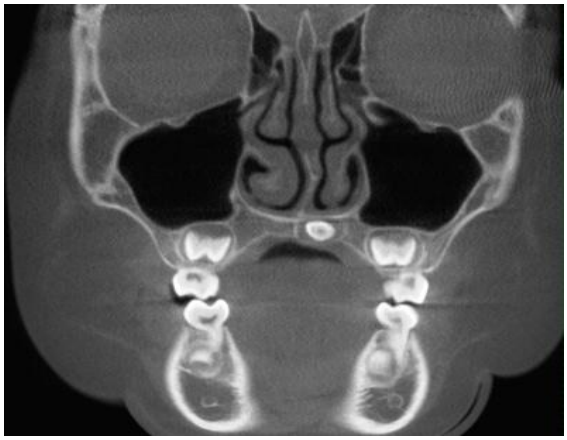

Fig. 5 The coronal section of CBCT shows an inverted tuberculate supernumerary tooth located in the palate

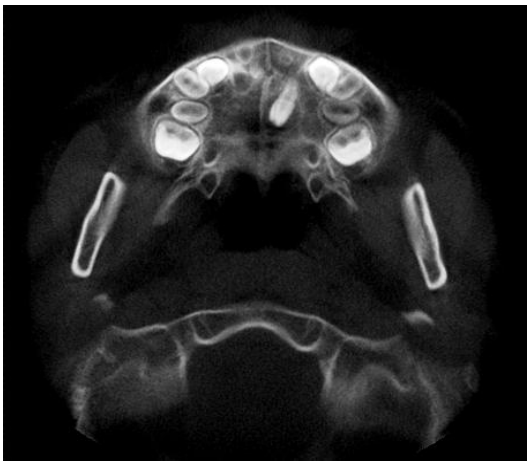

Fig. 6 The axial section of CBCT shows an inverted tuberculate supernumerary tooth located in the palate

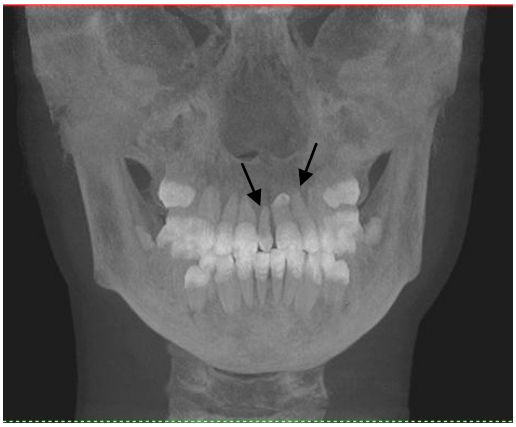

Fig. 7 The coronal or frontal CT shows an erupted conical peg shaped supernumerary tooth located between the maxillary central incisors and another inverted tuberculate supernumerary tooth located above the root of the maxillary left central incisor

Fig. 8 The sequence of sagittal tomograph shows an inverted palataly placed conical supernumerary tooth

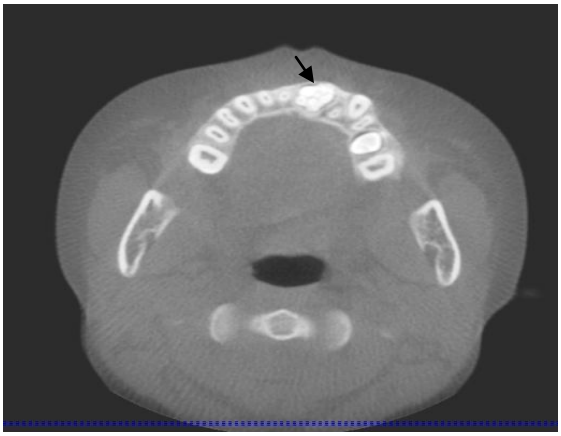

Fig. 9 The axial section tomograph shows an odontome located in the anterior maxilla

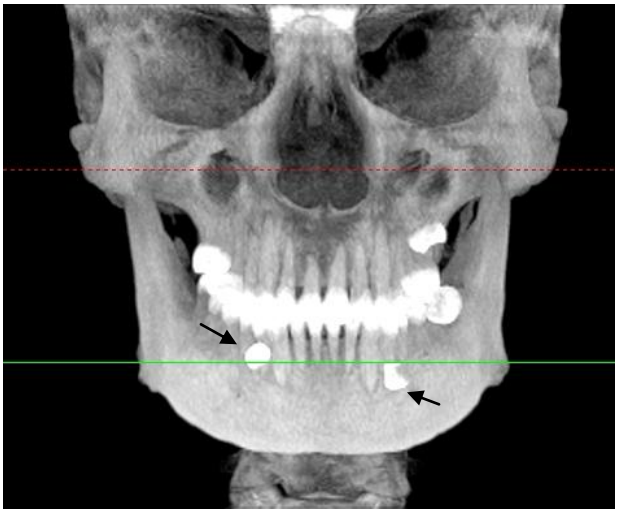

Fig. 10 The frontal tomography shows two parapremolar teeth on each side of lower jaw

Fig. 11 The frontal cone-beam tomograph shows an inverted conical supernumerary tooth located between the two central incisors in the anterior maxilla

Fig. 12 The coronal section tomograph shows an inverted tuberculate supernumerary tooth very close to the nasal cavity

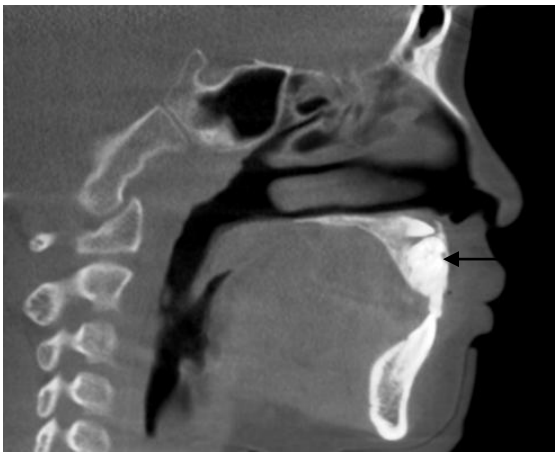

Fig. 13 The sequence of sagittal tomograph shows an odontome located in the anterior maxilla

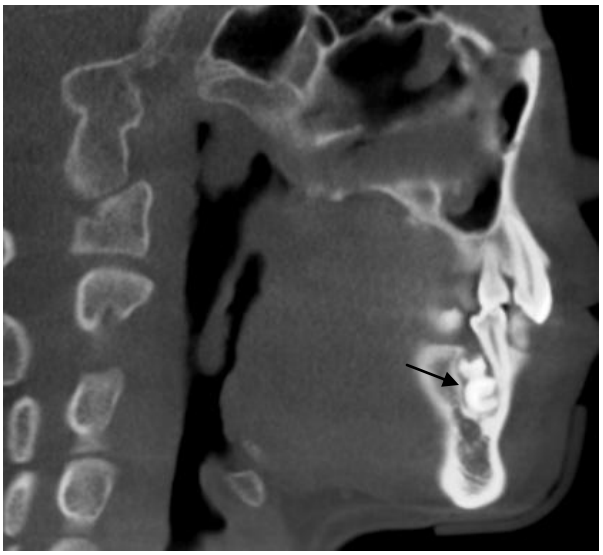

Fig. 14 The sequence of sagittal tomograph shows lingually placed impacted parapremolars in the mandible

Fig. 15 The sagittal tomograph shows an inverted tuberculate supernumerary tooth located in the palate

DISCUSSION

Supernumerary teeth may have a normal morphology or may be rudimentary and may have different shape anomalies. Supernumerary teeth may be found in mandible or maxilla or both with locational variations (anterior or posterior). Supernumerary teeth may be single, or multiple, and also may be erupted or impacted. Some cases of impacted supernumeraries are asymptomatic and are only detected during radiological examinations [1, 12]. Radiographs have been proved valuable in evaluation of the location, position, morphology, and nature of these anomalies for proper diagnosis and treatment planning.

Supernumerary teeth may occur in both dentitions, but they are most frequently seen in the permanent dentition [4]. The reported prevalence of supernumerary teeth in the general Caucasian population for the permanent dentition ranges from 0.1 to 3.8 % [1, 2, 7, 9, 13]. The reported prevalence of supernumerary teeth in the primary dentition ranges from 0.3 to 0.8% [1, 2]. The prevalence of supernumerary teeth found in this study was 20.7 %, which is unusual from the study conducted by most authors. Methodology for detection and the studied population could account for the cited range of prevalence.

Sexual dimorphism is reported by most authors with males being more commonly affected [1, 4, 14]. In a study conducted by Zilberman et al [12], the sex ratio was 2.5:1, again favoring 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 [15]. Yusof [2] stated a 9:2 male-female ratio in the occurrence of supernumerary teeth while Liu [3] reported a 3:1 ratio. In this study, the sex ratio was 2.6:1 in favor of males, a value that falls between the sex ratios reported for Caucasian populations [8, 9, 16]. The difference in sex ratio may be due to racial differences or possible sampling differences. Supernumerary teeth may occur in single, multiple, unilateral or bilateral in the maxilla,

mandible or both [1]. Grimanis G.A, Kyriakides A.T., Spyropoulus N.D. [17] found that supernumerary teeth occur more frequently in the maxilla (90%) than in the mandible (10%). In this study, the locations of diagnosed supernumerary teeth were found in a larger proportion in the maxilla (95%) than in the mandible (5%), in agreement with other studies [1, 17, 18].

Studies have shown that most frequent locations of supernumerary teeth are the anterior maxilla and the mandibular premolar regions in the permanent dentition [19]. The most common locations for supernumerary teeth are between maxillary central incisors, then mandibular premolar, maxillary molar, mandibular incisor, maxillary premolar and mandibular molar region [20]. In this study, the most frequent site for supernumerary teeth found was anterior maxilla followed by the mandibular premolar regions.

Supernumerary teeth appear in variety of shapes, Rajab and Hamdan [1] reported 74.8% conical, 11.9% tuberculate, 6.9% supplemental, and 6.4% odontoma among the study population. In this study sample, the most common variation in shape found was the conical type 71.6% (159 teeth), followed by the tuberculate type 22.5% (50 teeth), then the supplemental type 4% (9 teeth), and the odontoma 1.8% (4 teeth). Supernumerary teeth are most frequently single tooth [1, 3, 21, 22], while multiple supernumerary teeth appear frequently as two teeth [1, 3, 12, 22]. In this study, 80.5% (149 patients) had single supernumerary tooth, 18.9% (35 patients) had 2 supernumeraries and 0.5% (1 patient) had 3 supernumeraries. These results are in agreement with the other studies.

Supernumerary teeth may vary in position, they may develop in the direction of normal eruption, or may appear inverted, or transverse, or may assume an ectopic position, or follow an abnormal path of eruption. Supernumerary teeth could erupt normally or remain impacted and sometime asymptomatic. It has been found that approximately 25% of permanent supernumerary teeth were erupted, and the remainder 75% was unerupted [12, 13]. In contrast, Tay et al. [22] recorded a lower rate, of approximately 15%, of permanent supernumeraries erupted and Liu[4] reported a higher rate, of 34%. In the present study, 6.4% of the supernumerary teeth were erupted and 93.6% were found to be impacted. Liu [3] showed that supplemental teeth had a higher frequency of eruption. The high rate of impaction can be explained by later formation of supernumerary teeth in comparison to the normal teeth [17].

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 [16, 23]. Therefore, early diagnosis, proper evaluation and appropriate treatment are essential [16]. In clinical dentistry, it is often necessary to accurately locate supernumerary teeth and determine their relationship with adjacent teeth and other anatomical structures in the area, especially when extraction of supernumerary teeth or ectopically impacted teeth or orthodontic evaluation is needed. Determining the best surgical approach is of utmost importance to minimize harm to

adjacent tooth roots and trauma to the surrounding tissue [24]. 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 [25]. As a result, more advanced imaging techniques can, on occasion, is required.

In recent years, a new method, cone beam computed tomography (CBCT) has been introduced specifically for dental applications [26]. 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 [27]. Projections begin from the antero-posterior 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 3-D images are generated and optimized after selecting the region of interest and adjusting the angle and grey level [18]. CBCT produces 3-D information on the facial skeleton and teeth, and also it is increasingly being used in many of the dental specialities, including orthodontics, orthognathic surgery, trauma and implantology [28, 29]. 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 [25]. In addition, the use of CBCT technology in dentomaxillofacial imaging 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 lesser artifacts [30].

Radiographic examination is an essential component of the management of dental problems. The shape and position of supernumerary teeth and their potential effect on adjacent teeth should be taken into consideration while planning a treatment approach. 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.

CONCLUSION

The supernumerary teeth vary greatly in their shapes, position, location, or may be ectopic or may show an abnormal path of eruption. Most of supernumerary teeth are located in the anterior maxilla and are mesiodens. Conventional x-rays such as periapical, occlusal, paralleling techniques, and panoramic radiographs can present distortion and superimposition of dental structures and the three-dimensional anatomy of the tooth/teeth and adjacent structures is obscured.

The Cone-Beam Computed Tomography (CBCT) system provides considerably more information for oral diagnostic purposes. Sagittal, coronal and axial CBCT images eliminate the superimposition of anatomical structures and provide detail 3-D geometric accuracy. CBCT scans tend to result in a more objective and therefore more accurate determination of the position, angulation, and location of the supernumerary teeth.

According to the results, CBCT can offer useful information for diagnosis, detailed evaluation of supernumerary teeth and treatment planning that conventional radiographs are unable to provide.

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AUTHOR'S CONTRIBUTION

RPS- Data collection, principal conductor of this research and preparation of the first draft of manuscript; **FD-** Supervision, review, and approval of manuscript; **RG-** Data analysis and discussions.

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CONFLICT OF INTEREST: None declared.

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