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UTILIZATION OF CEPHALOMETRIC 2D AND 3D ANALYSIS DURING DIAGNOSIS, TREATMENT PLAN AND CASE MONITORING OF IMPACTED TEETH-CASE REPORT

Daniela Srbinoska[1], Vesna Trpevska[1], Elizabeta Cadikovska[2]
[1]Department of Orthodontics, University Dental Clinical Centre St. Panteleimon, Skopje, Republic of North Macedonia,
[2]Institute of anatomy, Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia.

Abstract

RTG projections are essential for diagnosis, treatment plan, follow-up and treatment outcomes. Three-dimensional (3D) cephalometry, which is done using a cone- beam computerized tomography (CBCT) examination, allows more detailed evaluation of the craniofacial hard and soft tissue structures than 2D radiograph. Using 3D analyses in diagnostic and treatment planning in orthodontics is more than necessary in cases with impacted teeth, cleft lip, and skeletal discrepancies requiring surgical interventions. CBCT has come into wider usage in other situations as root resorption, temporomandibular joint (TMJ) morphology and pathology, supernumerary teeth, alveolar boundary conditions and asymmetries; maxillary transverse dimensions and maxillary expansion; vertical malocclusion and obstructive sleep apnoea.

The present descriptive study aimed to explore possible applications of 3D technologies during the diagnosis, treatment plan, case monitoring and result assessment in orthodontics including their advantages and disadvantages.

Utilisation of 3D technique was more than necessary in diagnostic and treatment planning in this case because of presence of more than one impacted tooth. The fixed appliances, the surgical exposure, cortectomy and orthodontic traction were done. The tooth movement and positioning to the dental arch started six months ago.

The impacted tooth is already seen and the treatment continues. The severity of this case is indication for utilization of control 2D and 3D radiographs in manner following the positioning of the central incisor on the appropriate place. 3D technique is less prone to error and can improve the clinicians' workflow.

***Keywords**:* diagnosis, treatment plan, 2D radiograph, CBCT, cortectomy.

Introduction

RTG projections are essential for diagnosis, treatment plan, follow-up and treatment outcomes. CBCT has probably been one of the most revolutionary innovations in the field of dentistry in the past decade and it provides a novel platform for orthodontic diagnosis and treatment planning. Current imaging techniques are essentially two-dimensional (2D) representations of three-dimensional (3D) objects and suffer from several limitations.

Hence, fulfilment of ideal imaging goals has been limited. Cephalometric measurements, like all other measurements, involve errors that are classified as "errors of projection" and "errors of identification" due to the 2D head film, which causes a shadow of the 3D object [1,2].

2D radiographs are insufficient, especially in complex cases like impacted teeth, supernumerary teeth and orthognathic surgeries. CBCT images provide far more detailed information than conventional 2D radiographs and are user friendly. Soft tissues, skull, airway and the dentition can be observed and measured on CBCT images in a 1:1 ratio. CBCT has a clinical significance since it provides an excellent tool for accurate diagnosis, more predictable treatment planning, more efficient patient management and education, improved treatment outcome and patient satisfaction. Currently, three main methods are used for analysing 3D craniofacial anatomy and changes due to the treatment. The first method draws heavily from 2D cephalometric measurement methods to derive linear and angular measurements from 3D images [3,4].

The second method, called iterative closest point analysis, determines the shortest distances between structures in two superimposed 3D images but cannot be used to assess changes in shape [5,6].

The third method is shape correspondence, which determines the displacement of a given landmark between two time points and represents as vectors depicting number of movements, respectively [7,8].

Using 3D analyses in diagnostic and treatment planning in orthodontics is more than necessary in cases with impacted teeth for precise localization, cleft lip, skeletal discrepancies requiring surgical interventions as well as treatment cases with minis crews. CBCT has come into wider usage in other situations as root resorption, temporomandibular joint (TMJ) morphology and pathology, supernumerary teeth, alveolar boundary conditions and asymmetries; maxillary transverse dimensions and maxillary expansion; vertical malocclusion and obstructive sleep apnoea [9].

Utilization of CBCT in refining diagnosis and modifying treatment plans for significant numbers of impacted teeth validate its use for most impacted teeth which results in efficiency and enhanced success for tooth positioning. Failure of eruption associated with maxillary permanent incisor teeth usually presents between the ages of 7-9 years or in mixed dentition.

The eruption of maxillary incisors can be stopped about space loss because of early extraction or loss of primary teeth, obstruction, previous trauma, presence of localised pathology such as odontomas, supernumerary teeth or more rarely some cystic formation.

Maxillary central incisor is the third-most commonly impacted tooth after third permanent molars and maxillary canines. Impaction of maxillary incisor beyond the normal age-range warrants further investigation such as radiograph.

Cephalometric radiograph can be of value in the localisation and assessment of unerupted teeth, particularly in relation to the height of impaction and labio-palatal inclination of the crown and root of the tooth.

The development of maxillary canines occurs laterally to the piriform fossa. Such teeth have the most difficult eruption path, the longest period of development and the deepest area of development. Due to this, and their long and tortuous path of travel, maxillary canines are the most frequently impacted teeth after the third molars, with a prevalence of approximately 2%.

Preoperative prescription of 3D imaging such as CBCT is prescribed if the required information is not enough for degree of aberrant crown-root angulation and certainly helps in establishing an appropriate treatment plan. The success of surgical exposure combined with orthodontic traction has been reported to exceed 90% [10].

Rare condition is impaction of the first and second permanent molars in the daily practice of paediatric dentistry and orthodontics [11].

The incidence is only 0,08% and in 70% of the cases, the neighbouring ectopic third molar was determined to be the obstacle for normal eruption. The challenge is early diagnosis of this type of tooth impaction and usually conventional radiograph examinations are not enough because of the risks of damaging if the decision is removal of the third molar. Cases with impaction of more than one tooth are indication for CBCT [12].

Complexity of impaction tooth treatment varies widely, so management is a big challenge and needs a multidisciplinary specialist approach. 2D and 3D radiographs are more than necessary for diagnosis and treatment planning of impacted teeth. In general, treatment options depend on the age of the patient, severity of impaction, the amount of space available, type of malocclusion, oral health, patient motivation and opinion, bone anatomy and position of vital structures, as well as the circumstances of the patient (finances). Cooperation between different specialties (orthodontists, paediatric dentists, oral and maxillofacial surgeons), provides the best, individual results for each patient.

Case report

Treatment objectives

The primary objectives in our treatment were:

- to create anchorage for the orthodontic traction and incorporation of the impacted teeth into the dental arch;
- to regain slightly more space for impacted central incisor, regain space for impacted canine;
- keep the lateral incisor in the dental arch, and
- correct dental midline.

The other objectives were to establish a good occlusion, to obtain an optimal overbite-overjet relationship and to provide long-term retention, to enhance the health of the periodontium, and most importantly to improve dental and facial aesthetics.

Treatment diagnosis

A 10 -year-old girl with a permanent dentition was brought to our Clinic for orthodontic treatment 3 years ago. The chief complaint was aesthetic due to delayed eruption of the upper permanent central incisor. The medical history of the patient revealed that she suffered a traumatic injury to the anterior oral region when she was 3 years old. The patient had no complain of pain, no signs of infection and had a good oral hygiene. Clinical examination revealed normodivergent face and presence of good facial balance in all proportions.

Intraoral clinical examination revealed unilateral, left-side absence of permanent central incisor and maxillary canine and shifted midline. There was a space deficiency for teeth alignment. The patient revealed a limited mouth opening, microstomia. There was a cross bite of the left maxillary lateral incisor. The orthodontic treatment started with a mobile appliance combined with an oral surgical treatment, cortectomy. Cortectomy was done and we bonded incisor bracket.

The aim was to regain a space for the central incisor. The traction was with an elastic ligature connected to the mobile appliance arch attachment. The patient had no motivation and she didn't cooperate, so after 2 months she gave up.

One year ago, the same patient, now 13 years old, came again to our Clinic with better motivation for orthodontic treatment. There was unilateral, left-side impaction of maxillary permanent central incisor and permanent canine. The occlusal examination noted a bilateral Angle Class I, OJ was 2mm and OB 1mm (Fig.1 a, b, c, d).

Figure 1. Intraoral clinical examination of a 13-year-old patient: a) right view of Class I occlusion, b), cross bite of the left lateral incisor, c) upper occlusal view and d) delayed eruption of the left upper permanent central incisor and left upper canine.

The panoramic radiograph was done again. The panoramic radiograph revealed that all teeth were present (excluding the third molars, only left mandibular third molar was present). There was an impacted left maxillary permanent central incisor in the region of the nasal floor and suspected impaction of canine, therefore delayed eruption to the dental arch. The central incisor posture was horizontal. The permanent canine posture was suspected for lateral incisor root resorption. The adjacent lateral incisor was inclined towards the edentulous space (Fig.2).

Figure 2. Panoramic radiograph of a 13-year-old patient before treatment.

A CBCT was prescribed at this stage due to the impaction of two teeth and insufficient space. The CBCT showed areas with partial absence of alveolar bone and periodontal ligament on labial side of the central incisor. A lateral incisor root resorption was suspected because of the impacted canine position (Fig.3 a, b, c, d).

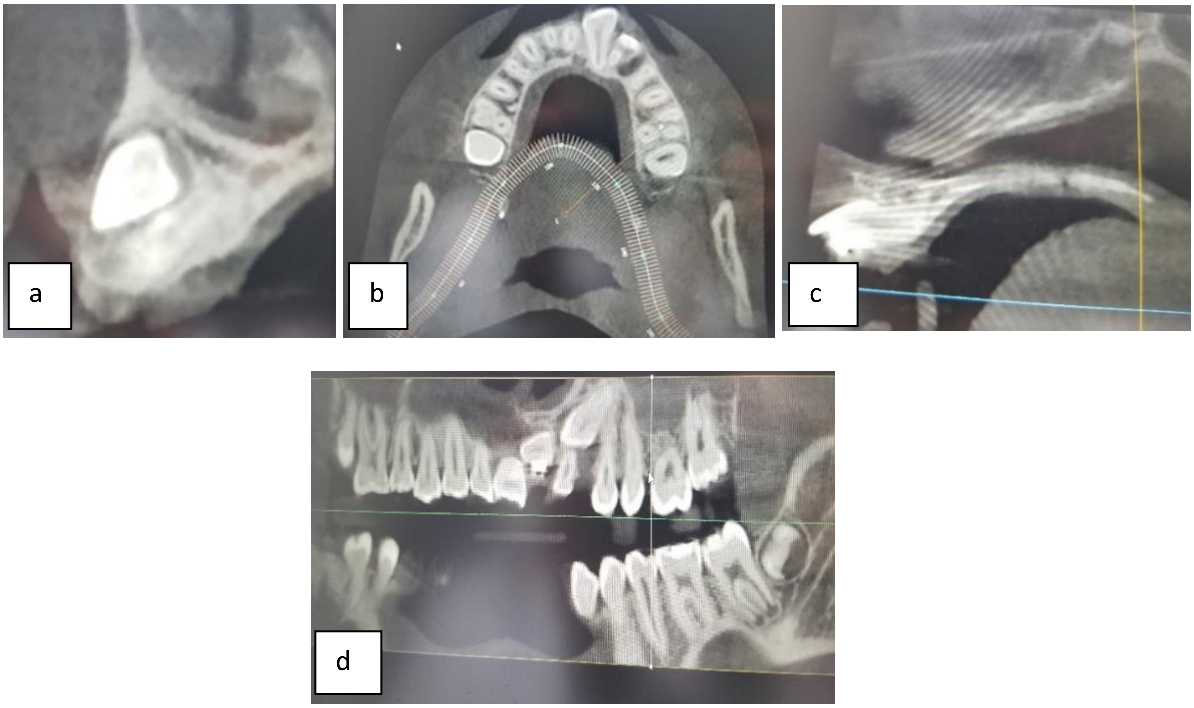

Figure 3. CBCT radiograph of a 13-year-old patient before treatment: a) labial view of partial absence of alveolar bone and periodontal ligament of the central incisor, b) occlusal view of upper dental arch, c) horizontal position of the central incisor and d) suspected lateral incisor root resorption.

Treatment plan

The present case describes the use of the straight-wire technique for the traction of the left upper central incisor. Based on patient's symptoms, extraoral and intraoral examination, as well as on panoramic radiograph and CBCT analysis, our treatment plan included:

- Consultation with an oral surgeon about cortectomy of the central incisor and later of the canine;
- The initial therapy started with fixed appliance which was placed one year ago. At the completion of the levelling and alignment phase, NiTi open-coil springs were used to open the space for the impacted central incisor in the first phase of treatment and
- Approximately six months ago, cortectomy was done again.

Standard incisor bracket was bonded in the same phase, so we started positioning the tooth in the dental arch (Fig.4). Gingival inflammation appeared on the cortectomy place, hence, the surgeon made revision and excision of the inflamed mucosa.

The risk of tooth losing was present because of the lack of bone on the labial side of the central incisor. Furthermore, the bad position of the canine was a risk for lateral incisor root resorption. After three months, the upper incisor emerged from the gingiva and reached a more occlusal position by traction with stainless steel ligature to the stainless-steel arch wire. The incisor was further extruded. At 6-month follow-up, the left maxillary incisor remained vital and responded normally to percussion, mobility and sensitivity with a good width of attached gingiva.

Figure 4. Cortectomy done six months ago, traction the incisor to the dental arch.

The treatment continues in manner to provide sufficient space and correct position of the tooth in the occlusal plane with good bone and periodontal support. The severity of this case is indication for utilization of control 2D and 3D radiographs in order to follow the positioning of the central incisor on the appropriate place.

Discussion

Proper diagnosis in orthodontic is required for successful treatment. The cephalogram is a standard method used by orthodontists to assess skeletal, dental and soft tissue relationships. Traditional 2D radiographs like panoramic view is used to evaluate the vertical position; occlusal X-ray to evaluate the proximity to adjacent teeth, and periapical radiographs to determine the labio-palatal position. The approach is based on 2D views used for the analysis of 3D objects.

However volumetric images are obtained from a CBCT scan. The analysis of 3D structures with 2D methodologies results in insufficient evidence and has inherent structural limitations, such as projection and identification errors, which has led orthodontists to search for new techniques [13].

In practice, a high level of accuracy is needed to use 3D image-based measurements, and this has been confirmed in many studies. As we move from traditional 2D cephalometric analysis to new 3D cephalometric techniques, it is often necessary to compare 2D with 3D images. However, besides all advantages radiography guidelines specify that 2D and 3D radiographs are not routinely indicated for any patient's diagnosis or treatment plan in any dental discipline, including orthodontics because the risk of unnecessary exposure to ionizing radiation [14-17].

When required, CBCT should be performed using the smallest possible field of view needed for the specific diagnosis or treatment planning [9].

Finally, the newest findings of the systematic reviews suggest also that 3D radiographs should be taken only when we expect to provide additional information that could be used in diagnosis or treatment planning [18,19].

CBCT-based 3D craniofacial and dental morphometrics has an important role in defining normal or abnormal 3D anatomy of structures and potential for long-term utility in diagnosis and treatment planning. One of the key advantages of CBCT over 2D radiography is its ability to provide 3D volumetric sectional and surface information about the craniofacial structures [20].

The main disadvantages of the 3D cephalometric analysis are high cost and high radiation exposure of CT. The majority of orthodontic patients are children in active growth. As we know radiation has a cumulative effect on the human body, and hence, any reduction in radiation exposure is beneficial [21].

The 2D cephalometric radiographs have been used successfully for over 70 years in orthodontics, and it appears that this method will survive for many more years. Nowadays, owing to the cost of CT scanning of the skull and radiation exposure patients, the 3D system is likely to be more suited to those cases with complex maxillofacial deformities, for diagnosis of patients requiring orthognathic surgery and patients with a severe form of tooth impaction, especially in cases with more than one tooth impaction as our presented case. Impacted teeth are ones in which CBCT has been most shown to improve diagnosis.

CBCT in manner enhances the ability to localize the teeth, evaluate their proximity to other teeth and structures, determine the follicle size and the presence estimate space conditions, assess resorption of adjacent teeth, assist in determining the optimal site for surgical intervention and aid in defining optimal direction for extrusion of these teeth into oral cavity. In fact, the indications for CBCT in impacted teeth are only if the inclination on a conventional 2D panoramic radiograph exceeds 30°, when adjacent root resorption is suspected, and/or when buccolingual direction not seen in 2D radiographs or root dilaceration is suspected on conventional panoramic radiographs.

Findings from studies demonstrate that the original treatment plans derived from 2D radiographs are changed for >25% of the impacted teeth when orthodontists viewed teeth in CBCT images as opposed to the 2D radiographs typically used for this purpose [22,23].

This case revealed that besides aiding in tooth localization, CBCT is also valuable in determining the optimal site for surgical access to an impacted tooth. Most of all, it contributes to significantly higher confidence in a clinician’s diagnosis and treatment planning than does the combination of panoramic and occlusal radiographs that traditionally have been used for this purpose [24, 25].

In particular, it is difficult to locate the impacted incisor tooth on the cephalograms of patients with crowded anterior teeth. However, with 3D CT imaging, these landmarks can be easily located and reliable measurements obtained. We need to note that many times, even with an early diagnosis of tooth impaction, as in our case, employing the surgical approach and appropriate orthodontic treatment is not possible. Young patients may not present adequate compliance for surgical intervention and for long-term cooperation as orthodontic treatment, so, the results directly depend on the age of the patient.

Conclusion

The orthopantomogram of patients at the age of 9, 10, and 11 years should be carefully evaluated by paediatric dentists and orthodontists. They should make an assessment about initiation of orthodontic treatment with regards to providing enough space and later prepared orthodontic traction because self-correction may not be the most frequent outcome in cases with tooth impaction.

The conventional techniques as 2D panoramic radiograph in severity cases with impacted tooth is considered to be especially arduous because of lack of information for precise diagnosis. Therefore, 3D technique is less prone to error and can improve the clinicians’ workflow. It has also shown minimization of the projection errors and identification of the cephalometric errors.

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