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**Diagnostic imaging: morphological and eruptive disturbances in the permanent teeth**

Sharma D *et al*. 3D diagnostic imaging techniques

Deepak Sharma, Ramneet Kaur, Suneet Monga, Simerjeet Kaur, Ruchika Kundra

**Deepak Sharma, Ramneet Kaur, Suneet Monga, Simerjeet Kaur, Ruchika Kundra,** Department of Pediatric and Preventive Dentistry, M. M. College of Dental Sciences and Research, Maharishi Markandeshwar University, Haryana 133207, India

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**Correspondence to: Deepak Sharma, Professor,** Department of Pediatric and Preventive Dentistry, M. M. College of Dental Sciences and Research, Maharishi Markandeshwar University, Mullana, Ambala, Haryana 133207, India. deepaksharmammu@gmail.com

**Telephone:** +91-9996-235933

**Fax:** +91-1731-304111

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**Abstract**

This paper reviewed the literature on newer three-dimensional imaging techniques and their applications in diagnosis and treatment planning of various dental anomalies. Developmental anomalies can occur during any of the developmental stages and are manifested clinically after the tooth is fully formed. These dental anomalies may involve a single tooth, a group of teeth, or the entire dentition. Two-dimensional diagnostic imaging, including periapical, occlusal, panoramic, or cephalometric radiographs are essential in localization and management of morphological and eruptive disorders. However, due to their inherent limitations such as insufficient precision because of unusual projection errors and lack of information about spatial relationships, these methods are considered unreliable. Thus, the use of newer image acquisition techniques that allow comprehensive three dimensional imaging and visualization of dental abnormalities is highly recommended for making a confirmatory diagnosis. The significance of accurate endodontic, surgical and orthodontic treatment planning in dental abnormalities cannot be overstated as it pertains to critical anatomic landmarks such as proximity to adjacent teeth or the mandibular canal. The precise information on spatial relationships provided by multiplanar imaging helps the dental surgeon to establish more accurate diagnosis, management strategies and also increases the patient safety. This review highlights the use of high-end diagnostic imaging modalities in diagnosis of the various morphologic and eruptive dental abnormalities

**Key words:** Three-dimensional imaging; Morphological disturbances; Eruptive malformations; Conebeam computed tomography; Spiral computed tomography; Magnetic resonance imaging

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**Core tip**: The advent of cone beam computed tomography, Spiral Computerized Tomography and Magnetic resonance imaging in the field of dental radiology has greatly facilitated access to the internal morphology of soft tissue and dental hard tissue structures. These techniques are beneficial in viewing spatial relationship of the suspected anomalous tooth and surrounding structures. Multiplanar imaging resolves the ambiguity of conventional two-dimensional radiographs by allowing the rotation of images at arbitrary angles without image magnifications and distortions.

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**INTRODUCTION**

Dental anomalies are expressed as morphological and eruption disorders. Morphological dental abnormalities occur due to disturbances during odontogenesis and it includes abnormality in number (supernumerary teeth), abnormality of tooth shape and size (dens in dente, dilaceration, fusion, root dwarfing)[1]. Eruption disturbances are mainly divided as disturbances related to time (premature eruption, delayed eruption or impactions) and disturbances related to position (ectopic eruption and transpositions).

A number of factors are responsible for eruptive and morphological dental abnormalities including genetic and congenital anomalies, metabolic disturbances, post operative complications of head and neck radiation therapy, use of chemotherapeutic agents, traumatic injuries to the primary dentition affecting the permanent tooth formation *etc.*[1,2].The embryologic tooth development of teeth starts around one and half month of intrauterine life and is characterized by distinct odontogenic stages including initiation, proliferation, histodifferentiation, morphodifferentiation, apposition, and calcification. Each stage has its own significance and disturbance at any stage may result into the development of an anomaly. The development of primary dentition occurs in a protected prenatal environment and duration of deciduous teeth development is small, therefore, they are less prone to dental abnormalities than the permanent teeth.

Radiographic method is considered to be advantageous for the preoperative determination of position and nature of these dental anomalies. Conventional plain film radiographic methods such as periapical, occlusal, panoramic, or cephalometric radiographs are a de-facto standard for diagnosis and treatment planning. However, due to their inherent limitations such as insufficient precision because of unusual projection errors and lack of information about spatial relationships, these methods are considered unreliable[3,4]. Earlier, computed tomography (CT) has been used widely in maxillofacial imaging to provide detailed 3-dimensional (3d) information. It forms an integral part in diagnosis of oral and maxillofacial regions as it facilitates access to the internal morphology of dentofacial structures. Its benefits of viewing spatial relationship of the anomalous tooth with surrounding structure by the rotation of images at arbitrary angles and absence of image magnification and distortions are well recognized and widely accepted in the literature. It is considered as more desirable morphometric tool than conventional plain film radiography[5-7]. However, it has certain limitations reducing its diagnostic reliability in dentistry including relatively low between-slice accuracy, no interslice gaps, artifacts, edge gradient effects and high radiation dose[8]. Recently, a series of conebeam computed tomography (CBCT) scans for three dimensional imaging of dentomaxillofacial region have been developed[8-13].The aim of the study is to present a systematic review of the literature on the diagnostic imaging of the morphological and eruptive disturbances in the permanent teeth.

**DIAGNOSTIC IMAGING TECHNIQUES FOR ASSESSMENT OF ERUPTIVE AND MORPHOLOGICAL DENTAL ANOMALIES**

CBCT is relatively newer image acquisition techniques that allow comprehensive multiplanar imaging and visualization of dental abnormalities in which resolution is measured in voxels[13,14]. It uses cone-shaped X-ray beam centered on a two-dimensional (2D) detector. The source-detector system performs one rotation around the object producing a series of 2D images. The 3D images are obtained by reformatting the 2D data in volume using a modification of the original cone-beam algorithm developed by Feldkamp *et al*[15] in 1984. CBCT scanners for the dentofacial region were originally developed in the late 1990s independently by Arai *et al*[16] in Japan and Mozzo *et al*[17] in Italy. CBCT has little projection effect and no magnification errors because X-ray beams are orthogonal, resulting in undistorted 1:1 measurements. It provides information for the entire craniofacial region[18,19] (Table 1).

**IMPACTED TEETH**

Impaction is defined as eruption failure of a tooth to its normal site in occlusion during its normal growth period because of malposition, lack of space, abnormal habit or mechanical obstruction in its eruption trajectory. The precise localization and diagnosis of an impacted tooth is required for proper surgical access and treatment planning. Nakajima *et al*[20] (2005) demonstrated the importance of CBCT image acquisition technique in cases of delayed eruption of the maxillary left second premolars and severe impaction of a maxillary second bicuspid. CT images provided more accurate information for orthodontic diagnosis and management strategies than conventional radiographic images such as precise observation of tooth morphology, root condition, and superimposition of bone.

***3D imaging in impacted permanent incisors***

Traumatic injuries to primary dentition cause eruptive malformations in underlying permanent tooth germs as they are in a close contact with their primary predecessors[21]. It may hinder the eruption pathway of the permanent tooth germ leading to delayed or failure of eruption[22]. The effect on the underlying tooth bud is related to its stage of odontogenesis, type and direction of impact[23].

Gurge *et al*[24] (2011) carried out CBCT imaging for comprehensive multiplanar evaluation, exact localization & conservative management of non erupted permanent upper lateral incisor with a previous history of a trauma through the primary predecessor in a 9 year-old patient. They highlighted the need for CBCT image acquisition techniques in the cases of impacted teeth where 3D visualization is necessary.

***Impacted 3rd molars***

Third molars are the most frequently impacted teeth. The dental literature has revealed these teeth are usually associated with pericoronitis, cheek biting, cysts, odontogenic tumors, and external root resorption of proximal teeth[25-29]. CBCT has proven to be an efficient method for evaluation of spatial relationship in different planes before deciding on management of impacted third molars.

Oenning *et al*[30] (2014) assessed external root resorption of second permanent molars associated with impacted third molars by conventional radiography and CBCT imaging. They observed significantly higher number of cases of ERR with CBCT imaging technique and highly recommended its use in cases of impaction specially mesioangular or horizontal impactions.

***Impacted canines***

Maxillary canines are the 2nd most commonly impacted teeth. Earlier tube shift technique was used to reveal the position of unerupted canine but the exact extent of displacement cannot be determined. CBCT imaging is beneficial in providing the accurate labial/palatal position and angulation of the impacted canine[3,31].

Walker *et al*[12] (2005) assessed the spatial relationship of impacted canines with adjacent structures and root resorption of incisor with the aid of 3D images produced from NewTom QR-DVT 9000. 3D volumetric imaging of impacted canines depicted the size of the follicle, inclination of the long axis of the tooth, relative buccal and palatal positions, bone covering the tooth, 3D proximity and resorption of roots of proximal teeth, local anatomic considerations and stage of dental development.

Liu *et al*[32] (2008) determined the position of 210 impacted maxillary canines and resorption of adjacent incisors with CBCT images. The angular and linear measurements depicted the spatial variations of the impacted canines which provided the picture for three dimensional relationships of the impactions relative to the adjacent dental arch.

Haney *et al*[18] (2010) compared differences in the diagnosis and treatment planning of impacted maxillary canines with traditional 2D imaging techniques and 3D CBCT volumetric images. The results yielded that the clinicians’ confidence in the accuracy of diagnosis and treatment plan was statistically greater for CBCT images (*P <* 0.001).

Alqerban *et al*[33] (2011) compared two CBCT systems versus traditional 2D imaging for assessing the location of impacted maxillary canine and identification of root resorption and observed that CBCT was more sensitive than panoramic radiography.

[Maverna](http://www.ncbi.nlm.nih.gov/pubmed?term=Maverna%20R%5BAuthor%5D&cauthor=true&cauthor_uid=17364031) *et al*[34] (2007) evaluated different radiographs for the localization of impacted maxillary canines (orthopantomography (OPT), laterolateral and posteroanteriorteleradiography, parallax method, laterolateral, occlusal radiography, computerized axial tomography, cone beam CT). They concluded that CBCT provided elements which escaped during traditional radiographic analysis and is therefore indicated in case of impacted teeth or cranio-facial structural anomalies.

**ECTOPIC ERUPTIONS**

Transposition is a rare type of ectopic eruption where a permanent tooth erupts in the position normally occupied by another permanent tooth[35-39]. Transposition are more frequently observed in upper arch (68.5%-76%) than in lower arch[39-42]. Maxillary canine and the first premolars are most commonly transpostioned[40].The ultimate success of the treatment plan is based upon accurate assessment and precise localization of the transposed teeth. Ericson and Kurol[43] (1987) reported that, in a sample of Swedish children, conventional periapical radiography successfully localized only 80% of ectopic canines. Rest 20% required tomography for exact localization especially in cases with overlapping lateral incisor (Table 1).

**TALON CUSP**

Talon cuspis an unusual morphological dental anomaly that is most commonly seen in the form of an accessory cusp-like structure projecting from the lingual or facial surface of anterior teeth[44]. A talon cusp is morphologically well-delineated. The appearance of projection is conical and resembles an eagle’s talon. Talon cusp may occur in both primary and permanent dentitions. It can occur in maxillary or mandibular anterior teeth. It is seen in both sexes[45].

Siraci *et al*[46] demonstrated unusual presentation of a talon cusp, occurring on both the facial and lingual surfaces of a supernumerary primary tooth. Existence of pulpal extensions was investigated using cone beam X-ray CT. It revealed distinct existence of pulpal extensions within the facial and palatal talon cusps. According to Mader and Kellogg[47],it was very difficult to distinguish the existence of a pulpal extension, which was confirmed in this case. Other two radiographs were taken from different angles but the interpretation of accessory pulp horns was uncertain which necessitated the utilization of a cone-beam CT for a correct diagnosis.

**ROOT DILACERATION**

Dilaceration is a developmental anomaly which occurs as a result of an abrupt change in the axial inclination between the crown and the root of a tooth. But the criteria in the literature for recognizing root dilaceration vary. Two possible causes of dilacerations are trauma and developmental disturbances. It has also been proposed that it might be associated with some developmental syndromes. Dilaceration is seen in both the permanent and deciduous dentitions, and it is more commonly found in posterior teeth and in the maxilla. Periapical radiographs are commonly used to diagnose the presence of root dilacerations[48].

Andrade *et al*[49] evaluated tooth displacement and root dilaceration after trauma to primary predecessor by computed tomography. The tomograms were analyzed using a dental computed tomography software program in order to evaluate the root formation of the upper right permanent central incisor and its position in the anterior alveolar process.

Mahesh *et al*[50] (2014) described the use of CBCT for the 10 year old patient with the complaint of non-eruption of the permanent maxillary right central and lateral incisors. A cone-beam CT scan was performed to assess the extent of dilaceration, if any, and to aid in the creation of a suitable treatment plan. It revealed palatal displacement of the crown and a gradual curvature in the apical 1/3rd of the root of right central incisor.

**SUPERNUMERARY TEETH**

Supernumerary teeth are a relatively frequent disorder of odontogenesis characterized by an excess number of teeth. It can be found in any region of the dental arch both in the primary and permanent dentition. Associated complications are failure of adjacent teeth to erupt, displacement and crowding of the adjacent teeth, abnormal diastema, root resorption.

Liu *et al*[14] (2007) used CBCT for evaluation of 626 supernumerary teeth in 487 patients. The ability of CBCT to visualize dental and skeletal structures relative to supernumerary teeth was also evaluated. A new system was proposed to classify the complex spatial location of supernumeraries in the maxillary anterior arch based on evaluation with CBCT. Type I, type II, and type VI were located palatal to the neighboring incisors in a variant craniocaudal position. Type III and type IV were seen within the dental arch, oriented normally, inverted, or in cross section. Type V was the supernumerary teeth located labially and superior to the incisor root and is rarest in occurrence. This classification system may yield an accurate picture for the 3-dimensional relationship of the supernumeraries relative to the adjacent dental structures, which is important during surgical or orthodontic evaluation. CBCT imaging yields accurate 3-dimensional pictures of local dental and bony structures, which is helpful for pretreatment evaluation of supernumerary teeth.

Supernumerary premolars are a rare anomaly in the maxillofacial complex. Its rarity and complex characteristics often makes it difficult to treat. CBCT plays an important role in assessment of both the location and the typing of supernumerary teeth[14,51,52].Thus, CBCT is crucial for exact localization which assists in proper treatment planning, and for the surgical approach in cases of multiple supernumerary teeth[53]. The benefits of CBCT imaging being low radiation dose and accurate diagnosis of the complex pathology in case of supernumerary teeth[54]. Odontomas are odontogenic tumours, resulting from epithelial growth and differentiated mesenchymal cells, clinically asymptomatic, and often associated with changes to the eruption of the permanent dentition. In recent years, CBCT has been used in the diagnosis and treatment planning of this condition[55].

**DENS INVAGINATUS**

Dens invaginatus (DI) is a dental developmental anomaly that results from invagination of the enamel organ into the dental papilla prior to the mineralization phase[56]. The cavity that forms in the case of dens invaginatus may serve as an external route of communication with the pulp or periapical tissues through the foramen caecum. The complexity of the internal anatomy in the case of dens invaginatus creates clinical challenges. Conventional periapical radiographs provide limited information regarding the anatomical configuration. The 3-dimensional imaging (CBCT) helps in identifying the morphology of the individual dens so that appropriate treatment planning and treatment options can be selected[57,58].

Patel *et al*[59] 2010 reported the use of CBCT in the assessment of chronic periradicular periodontitis associated with an infected invagination in an immature mandibular lateral incisor tooth. A CBCT scan revealed that there was no communication between the invagination and the main root canal. Endodontic treatment was carried out on the invagination. It was observed that that the true nature of dens invaginatus cannot be estimated from conventional radiographs accurately. Cone beam computed tomography is a useful diagnostic tool in the management of dens invaginatus.

Kaneko *et al*[60] (2011) described the use of CBCT to diagnose Oehlers' type III dens invaginatus in a maxillary lateral incisor. The CBCT scans demonstrated inaccessible and unfilled canal and invagination areas because of complex internal morphology. It was characterized by C- shaped cross-sectional canal configuration with constrictions at different points in different root levels and a prominent intraradicular cavity that was communicated with the enamel-lined invagination and opened into the apical periodontium. It was however judged that further endodontic treatment of the same was not feasible. CBCT helped in the diagnosis thus decision of avoiding further intervention was made that could have been difficult to negotiate.

Narayana *et al*[61] (2012) used CBCT to aid in the diagnosis and treatment-planning phase in 11-year-old male who reported for the treatment of maxillary right lateral incisor. 3-dimensional imaging helped in identifying the morphology of the individual dens which further guided the selection of the treatment provided. The morphology of the dens invaginatus was identified, and a periapical radiolucent area was detected that was not visible on a standard periapical radiograph.

Vier-Pelisser *et al*[62] (2012) presented the case of a maxillary left lateral incisor with Oehlers' type III dens invaginatus in which CBCT was used as an adjunctive resource in the diagnosis and in the planning and 2-year follow-up of the nonsurgical/surgical treatment. The CBCT scans revealed that the periapical radiolucency was significantly larger than seen radiographically and the increased thickness of the buccal cortical plate was also seen.

[Kfir](http://www.ncbi.nlm.nih.gov/pubmed?term=Kfir%20A%5BAuthor%5D&cauthor=true&cauthor_uid=23137215) *et al*[63] (2013) investigated the use of 3D plastic models, printed CBCT data, for accurate diagnosis and conservative treatment of a complex case of dens invaginatus. The CBCT scan provided with the information about the true nature of invagination and its relationship to the main canal. It was useful for demonstrating how the invagination had compressed the pulp space of the main canal at different levels which led to irregular main canal with a cross-section resembling a thin crescent encircling the invagination. It was also seen that there was no communication between the invagination and the pulp space.

Kato[64] (2013) described a case of surgical and non-surgical endodontic therapy for a maxillary lateral incisor with type III dens invaginatus with necrotic pulp and an associated large periradicular lesion. CBCT was used for three-dimensional observation of the morphological details of this area. It was observed that even complicated cases of dens invaginatus can be diagnosed and treated using non-surgical root canal management with the help of CBCT.

Dens invaginatus can also be associated with other abnormalities such as dysmorphic mesiodens. Though this condition can be detected by chance on the conventional radiography, the three-dimensional nature and the exact morphological patterns of DI can be determined by CBCT. Cantin *et al*[65] presented a morphological study of impacted mesiodens in a 9-year-old girl in whom the three coronal invaginations were detected only by CBCT.

The presence of double dens invaginatus is extremely rare. Understanding the type, extension, and complex morphology of dens invaginatus is essential for the proper treatment planning. Advanced imaging techniques, such as CBCT are very helpful in diagnosis of these complex anatomic variations as they give the 3 dimensional images unlike the conventional radiographic methods[66].

**FUSION**

Fusion also known as synodontia or false germination; occurs due to the union of 2 or more separately developing tooth germs at the dentinal level, presenting a single large tooth during odontogenesis, when the mineralization of crown is yet mineralized[67]. The prevalence of tooth fusion is estimated to be 0.5%–2.5% in primary dentition[68], whereas it is lower in permanent dentition. When fusion takes place between a normal tooth and a supernumerary tooth, the fused teeth shows an anomalous broad crown[69]. The pulp chambers and root canals can be joined or separated, depending on the stage of development when fusion took place[70]. Radiographic examination of fused teeth is important for management of endodontic problems. But the conventional intraoral periapical views produced only a 2d image which resulted in the superimposition of structures[71]. Nowadays a new diagnostic tool, CBCT, is being used in endodontics. Matherne *et al*[72] reported that CBCT imaging is useful in identifying root canal systems.

[Song](http://www.sciencedirect.com/science/article/pii/S0099239910006849) *et al*[73] discussed the endodontic management of a supernumerary tooth fused with a right maxillary first molar. They used CBCT for proper imaging of the same. Proper diagnosis and treatment planning can be done with the use of CBCT that further ensures predictable and successful results.

[Ferreira-Junior *et*](http://www.ncbi.nlm.nih.gov/pubmed?term=Ferreira-Junior%20O%5BAuthor%5D&cauthor=true&cauthor_uid=20690426) *al*[74] reported a case of fusion between an impacted third molar and a supernumerary tooth. The surgical intervention was carried out, with the objective of eliminating the dental elements. Proximity to the mandibular ramus made the final diagnosis difficult with panoramic radiography. Thus, CBCT was used to determinate the final diagnosis and also to help in the further surgical planning. It was observed that cone-beam computed tomography resulted in precise 3d information which was not possible with conventional radiography (Table 2).

Recently, a new CT technique *i.e.,* spiral computed tomography (SCT) also called volume acquisition CT, has been developed which has a significant advantage. It uses simultaneous patient translation through the X-ray source with continuous rotation of the source-detector assembly[75]. SCT acquires raw projection data with a spiral-sampling locus in a relatively short period[76]. The data can be viewed as conventional transaxial images without any additional scanning time. This technique makes reconstruction of overlapping structures at arbitrary intervals possible. Thus the ability to resolve small subjects is increased.

The unique arrangement of the gantry and rotating X-ray source assembly reduces scan times. With standard incremental CT, small objects can be missed or their detection compromised if the patient's degree of inspiration and expiration varies from scan to scan. Moreover, multiplanar and 3D image reconstructions of structures from standard incremental CT data are degraded by motion-induced misregistration artifacts[77].

[Ballal](http://www.sciencedirect.com/science/article/pii/S0099239907005961) *et al*[77] (2007) reported a rare case of successful endodontic management of unilateral fused mandibular second molar with a paramolar. The rarity and complexity of the entity makes it difficult to diagnose and treat. The use of diagnostic imaging modalities such as spiral SCT helps in forming a confirmatory diagnosis and treatment plan.

Metgud *et al*[78] (2009) reported a unique case with a unusual combination of morphological dental anomalies, including single conical non bifurcated posterior root forms, taurodontism, dens invaginatus, labial lobes of the canines, pyramidal cusps of the premolars, dens evaginatii of the molar crowns, and localized reduction in tooth size involving the entire dentition. It was not related with any other apparent systemic complication. The accurate assessment of the presence of single conical non bifurcated posterior root forms was done with the help of spiral computerized tomography.

[Gopikrishna](http://www.ncbi.nlm.nih.gov/pubmed?term=Gopikrishna%20V%5BAuthor%5D&cauthor=true&cauthor_uid=16793482) *et al*[79] (2006) reported a maxillary first molar with an unusual morphology of a single root and a single canal. An accurate assessment of this unusual morphology was made with the help of a Spiral computed tomography which was then endodontically managed.

Both case reports highlighted the use of high-end diagnostic imaging modalities such as spiral computerized tomography in diagnosis of the various morphologic abnormalities (Table 3).

3D imaging techniques are being utilized in dentistry beyond maxillofacial surgical planning. Dental magnetic resonance imaging (MRI) is technique that adds a third dimension to treatment planning other then on CT and digital volume tomography.

MRI, is quite new in the field of dental radiology. The technique does not use ionizing radiation and is safe when no contraindications are present such as (cardiac pacemakers, implanted cardiac defibrillators, aneurysm clips, neurostimulators, metallic foreign bodies in the eyes, *etc.*). It has no limitations in the frequency of examinations. MRI is based on the nuclear magnetic resonance phenomenon, which takes place when nuclei of certain atoms (usually hydrogen in medicine) are placed in a strong static magnetic field and absorb energy of an alternating magnetic field of a specific, resonant frequency. The use of spatially varying magnetic fields makes it possible to spatially encode the nuclei and perform tomographic imaging.

The signal measured on MRI usually originates from soft tissues and liquids in the human body. The teeth and jawbone appear black in images taken by MRI due to low water content and short relaxation constants of hydrogen atoms. The dental pulp, jawbone marrow, mandibular canal containing the mandibular artery and vein and the alveolar nerve, saliva, gingiva, facial soft tissues, tongue, and palate produce a signal on clinical MRI. But there is no measurable signal from dental enamel, dentin, cortical bone, and air. The structures that do not produce any sign can also be measured indirectly from the contrast with adjacent signal-emitting structures.

MRI enables 3D measurement of the mandible because of the contrast between the cortical bone and the surrounding soft tissue[80]. Impacted teeth can be visualized and their positions in all 3 dimensions can be assessed. As there is difference in contrast between the teeth and the surrounding tissue, such as the gingiva, tongue, cheek, saliva, and jaw bone marrow[81].The most significant advantage of dental MRI is the complete absence of ionizing radiation when compared to other 3D imaging techniques.

Tymofiyeva *et al*[81] (2009) discussed economic aspects and technical properties of MRI compared with cone-beam CT in diagnosing impacted teeth.Gaudino *et al*[82] (2011) reported that MRI shows a comparable accuracy and better visibility in the detection of teeth and periodontal anatomy compared with cone-beam CT.

Tymofiyeva *et al*[83] (2013) assessed the feasibility of MRI of dental abnormalities in 16 patients (mean age, 10.8 years). The selected patients included 3 with a mesiodens, 9 with supernumerary teeth other than a mesiodens, 1 with gemination, 1 with dilacerations, 1 with transmigration, and 1 with transposition. MRI was found to be a suitable imaging modality for the diagnosis of dental abnormalities in children and for orthodontic treatment and surgical planning. MRI had various advantages when compared with conventional radiographic methods such a; 3 dimensionality and complete elimination of ionizing radiation, which is relevant for repeated examinations in children.

**CONCLUSION**

In conclusion, the results of this review showed that 3D imaging techniques are crucial for exact localization and provides precise three dimensional information on spatial relationships by depicting the size of the follicle, inclination of the long axis of the tooth, relative buccal and palatal positions, bone covering the tooth, proximity and resorption of roots of proximal teeth, local anatomic considerations and stage of dental development. Thus, the use of newer image acquisition techniques such as Cone Beam Computed Tomography, Spiral Computerized Tomography and Magnetic Resonance Imagingare advocated for final diagnosis and precise treatment planning of eruptive and morphological dental anomalies.

**REFERENCES**

1 **Bazan MT**. Anomalous dental development with medical and genetic implications. *Pediatr Ann* 1985; **14**: 108-11, 114, 116 [PMID: 3991243 DOI: 10.3928/0090-4481-19850201-07]

2 **Shah N**. Extraoral tooth eruption and transposition of teeth following trauma. *Endod Dent Traumatol* 1994; **10**: 195-197 [PMID: 7995253 DOI: 10.1111/j.1600-9657.1994.tb00687.x]

3 **Chaushu S**, Chaushu G, Becker A. The role of digital volume tomography in the imaging of impacted teeth. *World J Orthod* 2004; **5**: 120-132 [PMID: 15615130]

4 **Kim KD**, Ruprecht A, Jeon KJ, Park CS. Personal computer-based three-dimensional computed tomographic images of the teeth for evaluating supernumerary or ectopically impacted teeth. *Angle Orthod* 2003; **73**: 614-621 [PMID: 14580032]

5 **Ekestubbe A**, Gröndahl K, Gröndahl HG. The use of tomography for dental implant planning. *Dentomaxillofac Radiol* 1997; **26**: 206-213 [PMID: 9442610 DOI: 10.1038/sj.dmfr.4600249]

6 **King JM**, Caldarelli DD, Petasnick JP. DentaScan: a new diagnostic method for evaluating mandibular and maxillary pathology. *Laryngoscope* 1992; **102**: 379-387 [PMID: 1556886 DOI: 10.1288/00005537-199204000-00003]

7 **Bodner L**, Bar-Ziv J, Kaffe I. CT of cystic jaw lesions. *J Comput Assist Tomogr* 1994; **18**: 22-26 [PMID: 8282877 DOI: 10.1097/00004728-199401000-00005]

8 **Schulze D**, Heiland M, Thurmann H, Adam G. Radiation exposure during midfacial imaging using 4- and 16-slice computed tomography, cone beam computed tomography systems and conventional radiography. *Dentomaxillofac Radiol* 2004; **33**: 83-86 [PMID: 15313998 DOI: 10.1259/dmfr/28403350]

9 **Ziegler CM**, Woertche R, Brief J, Hassfeld S. Clinical indications for digital volume tomography in oral and maxillofacial surgery. *Dentomaxillofac Radiol* 2002; **31**: 126-130 [PMID: 12076053 DOI: 10.1038/sj.dmfr.4600680]

10 **Terakado M**, Hashimoto K, Arai Y, Honda M, Sekiwa T, Sato H. Diagnostic imaging with newly developed ortho cubic super-high resolution computed tomography (Ortho-CT). *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2000; **89**: 509-518 [PMID: 10760735 DOI: 10.1016/S1079-2104(00)70133-8]

11 **Yamamoto K**, Hayakawa Y, Kousuge Y, Wakoh M, Sekiguchi H, Yakushiji M, Farman AG. Diagnostic value of tuned-aperture computed tomography versus conventional dentoalveolar imaging in assessment of impacted teeth. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2003; **95**: 109-118 [PMID: 12539036 DOI: 10.1067/moe.2003.17]

12 **Walker L**, Enciso R, Mah J. Three-dimensional localization of maxillary canines with cone-beam computed tomography. *Am J Orthod Dentofacial Orthop* 2005; **128**: 418-423 [PMID: 16214621 DOI: 10.1016/j.ajodo.2004.04.033]

13 **Hashimoto K**, Arai Y, Iwai K, Araki M, Kawashima S, Terakado M. A comparison of a new limited cone beam computed tomography machine for dental use with a multidetector row helical CT machine. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2003; **95**: 371-377 [PMID: 12627112 DOI: 10.1067/moe.2003.120]

14 **Liu DG**, Zhang WL, Zhang ZY, Wu YT, Ma XC. Three-dimensional evaluations of supernumerary teeth using cone-beam computed tomography for 487 cases. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2007; **103**: 403-411 [PMID: 17321454 DOI: 10.1016/j.tripleo.2006.03.026]

15 **Feldkamp LA**, Davis LC, Kress JW. Practical cone-beam algorithm. *J Opt Soc Am A Opt Image Sci Vis* 1984; **1**: 612–619 [doi: 10.1364/JOSAA.1.000612]

16 **Arai Y**, Tammisalo E, Iwai K, Hashimoto K, Shinoda K. Development of a compact computed tomographic apparatus for dental use. *Dentomaxillofac Radiol* 1999; **28**: 245-248 [PMID: 10455389 DOI: 10.1038/sj.dmfr.4600448]

17 **Mozzo P**, Procacci C, Tacconi A, Martini PT, Andreis IA. A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. *Eur Radiol* 1998; **8**: 1558-1564 [PMID: 9866761 DOI: 10.1007/s003300050586]

18 **Haney E**, Gansky SA, Lee JS, Johnson E, Maki K, Miller AJ, Huang JC. Comparative analysis of traditional radiographs and cone-beam computed tomography volumetric images in the diagnosis and treatment planning of maxillary impacted canines. *Am J Orthod Dentofacial Orthop* 2010; **137**: 590-597 [PMID: 20451777 DOI: 10.1016/j.ajodo.2008.06.035]

19 **Cevidanes LH**, Styner MA, Proffit WR. Image analysis and superimposition of 3-dimensional cone-beam computed tomography models. *Am J Orthod Dentofacial Orthop* 2006; **129**: 611-618 [PMID: 16679201 DOI: 10.1016/j.ajodo.2005.12.008]

20 **Nakajima A**, Sameshima GT, Arai Y, Homme Y, Shimizu N, Dougherty H. Two- and three-dimensional orthodontic imaging using limited cone beam-computed tomography. *Angle Orthod* 2005; **75**: 895-903 [PMID: 16448229]

21 **Sakai VT**, Moretti AB, Oliveira TM, Silva TC, Abdo RC, Santos CF, Machado MA. Replantation of an avulsed maxillary primary central incisor and management of dilaceration as a sequel on the permanent successor. *Dent Traumatol* 2008; **24**: 569-573 [PMID: 18821966 DOI: 10.1111/j.1600-9657.2008.00583.x]

22 **Kamat SS**, Kumar GS, Raghunath V, Rekha KP. Permanent maxillary central incisor impaction: report of two cases. *Quintessence Int* 2003; **34**: 50-52 [PMID: 12674359]

23 **Montalvo-Polk A**, Kittle PE. Impaction and malformation of a maxillary central incisor: sequelae of trauma. *ASDC J Dent Child* 1993; **60**: 29-32 [PMID: 8432943]

24 **Gurgel CV**, Lourenço Neto N, Kobayashi TY, Garib DG, da Silva SM, Machado MA, Oliveira TM. Management of a permanent tooth after trauma to deciduous predecessor: an evaluation by cone-beam computed tomography. *Dent Traumatol* 2011; **27**: 408-412 [PMID: 21645241]

25 **Knutsson K**, Brehmer B, Lysell L, Rohlin M. Pathoses associated with mandibular third molars subjected to removal. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1996; **82**: 10-17 [PMID: 8843448]

26 **Yamalik K**, Bozkaya S. The predictivity of mandibular third molar position as a risk indicator for pericoronitis. *Clin Oral Investig* 2008; **12**: 9-14 [PMID: 17619915]

27 **Akarslan ZZ**, Kocabay C. Assessment of the associated symptoms, pathologies, positions and angulations of bilateral occurring mandibular third molars: is there any similarity? *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009; **108**: e26-e32 [PMID: 19716488]

28 **van der Linden W**, Cleaton-Jones P, Lownie M. Diseases and lesions associated with third molars. Review of 1001 cases. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1995; **79**: 142-145 [PMID: 7614173]

29 **Falci SG**, de Castro CR, Santos RC, de Souza Lima LD, Ramos-Jorge ML, Botelho AM, Dos Santos CR. Association between the presence of a partially erupted mandibular third molar and the existence of caries in the distal of the second molars. *Int J Oral Maxillofac Surg* 2012; **41**: 1270-1274 [PMID: 22464852 DOI: 10.1016/j.ijom.2012.03.003]

30 **Oenning AC**, Neves FS, Alencar PN, Prado RF, Groppo FC, Haiter-Neto F. External root resorption of the second molar associated with third molar impaction: comparison of panoramic radiography and cone beam computed tomography. *J Oral Maxillofac Surg* 2014; **72**: 1444-1455 [PMID: 24856956 DOI: 10.1016/j.joms.2014.03.023]

31 **Hechler SL**. Cone-beam CT: applications in orthodontics. *Dent Clin North Am* 2008; **52**: 809-23, vii [PMID: 18805230 DOI: 10.1016/j.cden.2008.05.001]

32 **Liu DG**, Zhang WL, Zhang ZY, Wu YT, Ma XC. Localization of impacted maxillary canines and observation of adjacent incisor resorption with cone-beam computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2008; **105**: 91-98 [PMID: 17507268 DOI: 10.1016/j.tripleo.2007.01.030]

33 **Alqerban A**, Jacobs R, Fieuws S, Willems G. Comparison of two cone beam computed tomographic systems versus panoramic imaging for localization of impacted maxillary canines and detection of root resorption. *Eur J Orthod* 2011; **33**: 93-102 [PMID: 21270321 DOI: 10.1093/ejo/cjq034]

34 **Maverna R**, Gracco A. Different diagnostic tools for the localization of impacted maxillary canines: clinical considerations. *Prog Orthod* 2007; **8**: 28-44 [PMID: 17364031]

35 **Shapira Y**, Kuftinec MM, Stom D. Maxillary canine-lateral incisor transposition--orthodontic management. *Am J Orthod Dentofacial Orthop* 1989; **95**: 439-444 [PMID: 2718974 DOI: 10.1016/0889-5406(89)90306-5]

36 **Maia FA**. Orthodontic correction of a transposed maxillary canine and lateral incisor. *Angle Orthod* 2000; **70**: 339-348 [PMID: 10961785]

37 **Yilmaz HH**, Türkkahraman H, Sayin MO. Prevalence of tooth transpositions and associated dental anomalies in a Turkish population. *Dentomaxillofac Radiol* 2005; **34**: 32-35 [PMID: 15709103 DOI: 10.1259/dmfr/57695636]

38 **Burnett SE**. Prevalence of maxillary canine-first premolar transposition in a composite African sample. *Angle Orthod* 1999; **69**: 187-189 [PMID: 10227560]

39 **Ruprecht A**, Batniji S, El-Neweihi E. The incidence of transposition of teeth in dental patients. *J Pedod* 1985; **9**: 244-249 [PMID: 3858501]

40 **Ely NJ**, Sherriff M, Cobourne MT. Dental transposition as a disorder of genetic origin. *Eur J Orthod* 2006; **28**: 145-151 [PMID: 16373452 DOI: 10.1093/ejo/cji092]

41 **Plunkett DJ**, Dysart PS, Kardos TB, Herbison GP. A study of transposed canines in a sample of orthodontic patients. *Br J Orthod* 1998; **25**: 203-208 [PMID: 9800019 DOI: 10.1093/ortho/25.3.203]

42 **Peck S**, Peck L. Classification of maxillary tooth transpositions. *Am J Orthod Dentofacial Orthop* 1995; **107**: 505-517 [PMID: 7733060 DOI: 10.1016/S0889-5406(95)70118-4]

43 **Ericson S**, Kurol J. Radiographic examination of ectopically erupting maxillary canines. *Am J Orthod Dentofacial Orthop* 1987; **91**: 483-492 [PMID: 3473928 DOI: 10.1016/0889-5406(87)90005-9]

44 **Davis PJ**, Brook AH. The presentation of talon cusp: diagnosis, clinical features, associations and possible aetiology. *Br Dent J* 1986; **160**: 84-88 [PMID: 3456236 DOI: 10.1038/sj.bdj.4805774]

45 **Mader CL**. Talon cusp. *J Am Dent Assoc* 1981; **103**: 244-246 [PMID: 6943189]

46 **Siraci E**, Cem Gungor H, Taner B, Cehreli ZC. Buccal and palatal talon cusps with pulp extensions on a supernumerary primary tooth. *Dentomaxillofac Radiol* 2006; **35**: 469-472 [PMID: 17082342 DOI: 10.1259/dmfr/64715224]

47 **Mader CL**, Kellogg SL. Primary talon cusp. *ASDC J Dent Child* 1985; **52**: 223-226 [PMID: 3859512]

48 **Jafarzadeh H**, Abbott PV. Dilaceration: review of an endodontic challenge. *J Endod* 2007; **33**: 1025-1030 [PMID: 17931926 DOI: 10.1016/j.joen.2007.04.013]

49 **Andrade MG**, Weissman R, Oliveira MG, Heitz C. Tooth displacement and root dilaceration after trauma to primary predecessor: an evaluation by computed tomography. *Dent Traumatol* 2007; **23**: 364-367 [PMID: 17991237 DOI: 10.1111/j.1600-9657.2006.00475.x]

50 **R M**, Ig K, M S. Dilaceration and Eruption Disturbances in Permanent Teeth: A Sequelae of Trauma to Their Predecessors-Diagnosis and Treatment Using Cone Beam CT. *J Clin Diagn Res* 2014; **8**: ZD10-ZD12 [PMID: 24995254 DOI: 10.7860/JCDR/2014/6657.4342]

51 **Merrett SJ**, Drage N, Siphahi SD. The use of cone beam computed tomography in planning supernumerary cases. *J Orthod* 2013; **40**: 38-46 [PMID: 23524546 DOI: 10.1179/1465313312Y.0000000029]

52 **Gurgel CV**, Costa AL, Kobayashi TY, Rios D, Silva SM, Machado MA, Oliveira TM. Cone beam computed tomography for diagnosis and treatment planning of supernumerary teeth. *Gen Dent* 2012; **60**: e131-e135 [PMID: 22623467]

53 **Katheria BC**, Kau CH, Tate R, Chen JW, English J, Bouquot J. Effectiveness of impacted and supernumerary tooth diagnosis from traditional radiography versus cone beam computed tomography. *Pediatr Dent* 2010; **32**: 304-309 [PMID: 20836949]

54 **Brauer HU**. Case report: non-syndromic multiple supernumerary teeth localized by cone beam computed tomography. *Eur Arch Paediatr Dent* 2010; **11**: 41-43 [PMID: 20129033 DOI: 10.1007/BF03262709]

55 **Kobayashi TY**, Gurgel CV, Cota AL, Rios D, Machado MA, Oliveira TM. The usefulness of cone beam computed tomography for treatment of complex odontoma. *Eur Arch Paediatr Dent* 2013; **14**: 185-189 [PMID: 23633234 DOI: 10.1007/s40368-013-0036-5]

56 **Reddy YP**, Karpagavinayagam K, Subbarao CV. Management of dens invaginatus diagnosed by spiral computed tomography: a case report. *J Endod* 2008; **34**: 1138-1142 [PMID: 18718382 DOI: 10.1016/j.joen.2008.06.001]

57 **Cohenca N**, Berg J. Diagnosis and conservative treatment of dens invaginatus type III using cone beam computed tomography: two case reports. *Pediatr Dent* 2013; **35**: E33-E37 [PMID: 23635895]

58 **Durack C**, Patel S. The use of cone beam computed tomography in the management of dens invaginatus affecting a strategic tooth in a patient affected by hypodontia: a case report. *Int Endod J* 2011; **44**: 474-483 [PMID: 21314830 DOI: 10.1111/j.1365-2591.2011.01866.x]

59 **Patel S**. The use of cone beam computed tomography in the conservative management of dens invaginatus: a case report. *Int Endod J* 2010; **43**: 707-713 [PMID: 20500234 DOI: 10.1111/j.1365-2591.2010.01734.x]

60 **Kaneko T**, Sakaue H, Okiji T, Suda H. Clinical management of dens invaginatus in a maxillary lateral incisor with the aid of cone-beam computed tomography--a case report. *Dent Traumatol* 2011; **27**: 478-483 [PMID: 21752188 DOI: 10.1111/j.1600-9657.2011.01021.x]

61 **Narayana P**, Hartwell GR, Wallace R, Nair UP. Endodontic clinical management of a dens invaginatus case by using a unique treatment approach: a case report. *J Endod* 2012; **38**: 1145-1148 [PMID: 22794224 DOI: 10.1016/j.joen.2012.04.020]

62 **Vier-Pelisser FV**, Pelisser A, Recuero LC, Só MV, Borba MG, Figueiredo JA. Use of cone beam computed tomography in the diagnosis, planning and follow up of a type III dens invaginatus case. *Int Endod J* 2012; **45**: 198-208 [PMID: 21978185 DOI: 10.1111/j.1365-2591.2011.01956.x]

63 **Kfir A**, Telishevsky-Strauss Y, Leitner A, Metzger Z. The diagnosis and conservative treatment of a complex type 3 dens invaginatus using cone beam computed tomography (CBCT) and 3D plastic models. *Int Endod J* 2013; **46**: 275-288 [PMID: 23137215 DOI: 10.1111/iej.12013]

64 **Kato H**. Non-surgical endodontic treatment for dens invaginatus type III using cone beam computed tomography and dental operating microscope: a case report. *Bull Tokyo Dent Coll* 2013; **54**: 103-108 [PMID: 23903581 DOI: 10.2209/tdcpublication.54.103]

65 **Cantín M**, Fonseca GM. Dens invaginatus in an impacted mesiodens: a morphological study. *Rom J Morphol Embryol* 2013; **54**: 879-884 [PMID: 24322044]

66 **Dinapadu S**, Aravelli S, Pasari S, Marukala NR. A rare presentation of bilateral maxillary dens invaginatus diagnosed using cone beam computed tomography. *J Clin Imaging Sci* 2013; **3**: 8 [PMID: 24516771 DOI: 10.4103/2156-7514.119126]

67 **Velasco LF**, de Araujo FB, Ferreira ES, Velasco LE. Esthetic and functional treatment of a fused permanent tooth: a case report. *Quintessence Int* 1997; **28**: 677-680 [PMID: 9477888]

68 **Blaney TD**, Hartwell GR, Bellizzi R. Endodontic management of a fused tooth: a case report. *J Endod* 1982; **8**: 227-230 [PMID: 6955423 DOI: 10.1016/S0099-2399(82)80359-2]

69 **Hülsmann M**, Bahr R, Grohmann U. Hemisection and vital treatment of a fused tooth--literature review and case report. *Endod Dent Traumatol* 1997; **13**: 253-258 [PMID: 9558505 DOI: 10.1111/j.1600-9657.1997.tb00051.x]

70 **Brook AH**, Winter GB. Double teeth. A retrospective study of 'geminated' and 'fused' teeth in children. *Br Dent J* 1970; **129**: 123-130 [PMID: 5272471 DOI: 10.1038/sj.bdj.4802533]

71 **Tachibana H**, Matsumoto K. Applicability of X-ray computerized tomography in endodontics. *Endod Dent Traumatol* 1990; **6**: 16-20 [PMID: 2390962 DOI: 10.1111/j.1600-9657.1990.tb00381.x]

72 **Matherne RP**, Angelopoulos C, Kulild JC, Tira D. Use of cone-beam computed tomography to identify root canal systems in vitro. *J Endod* 2008; **34**: 87-89 [PMID: 18155501 DOI: 10.1016/j.joen.2007.10.016]

73 **Song CK**, Chang HS, Min KS. Endodontic management of supernumerary tooth fused with maxillary first molar by using cone-beam computed tomography. *J Endod* 2010; **36**: 1901-1904 [PMID: 20951310 DOI: 10.1016/j.joen.2010.08.026]

74 **Ferreira-Junior O**, de Avila LD, Sampieri MB, Dias-Ribeiro E, Chen WL, Fan S. Impacted lower third molar fused with a supernumerary tooth--diagnosis and treatment planning using cone-beam computed tomography. *Int J Oral Sci* 2009; **1**: 224-228 [PMID: 20690426 DOI: 10.4248/IJOS09056]

75 **Kalender WA**, Seissler W, Klotz E, Vock P. Spiral volumetric CT with single-breath-hold technique, continuous transport, and continuous scanner rotation. *Radiology* 1990; **176**: 181-183 [PMID: 2353088 DOI: 10.1148/radiology.176.1.2353088]

76 **Vannier MW**, Hildebolt CF, Conover G, Knapp RH, Yokoyama-Crothers N, Wang G. Three-dimensional dental imaging by spiral CT. A progress report. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1997; **84**: 561-570 [PMID: 9394390 DOI: 10.1016/S1079-2104(97)90274-2]

77 **Ballal S**, Sachdeva GS, Kandaswamy D. Endodontic management of a fused mandibular second molar and paramolar with the aid of spiral computed tomography: a case report. *J Endod* 2007; **33**: 1247-1251 [PMID: 17889700 DOI: 10.1016/j.joen.2007.06.021]

78 **Metgud S**, Metgud R, Rani K. Management of a patient with a taurodont, single-rooted molars associated with multiple dental anomalies: a spiral computerized tomography evaluation. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2009; **108**: e81-e86 [PMID: 19615651 DOI: 10.1016/j.tripleo.2009.04.014]

79 **Gopikrishna V**, Bhargavi N, Kandaswamy D. Endodontic management of a maxillary first molar with a single root and a single canal diagnosed with the aid of spiral CT: a case report. *J Endod* 2006; **32**: 687-691 [PMID: 16793482]

80 **Nasel CJ**, Pretterklieber M, Gahleitner A, Czerny C, Breitenseher M, Imhof H. Osteometry of the mandible performed using dental MR imaging. *AJNR Am J Neuroradiol* 1999; **20**: 1221-1227 [PMID: 10472975]

81 **Tymofiyeva O**, Rottner K, Jakob PM, Richter EJ, Proff P. Three-dimensional localization of impacted teeth using magnetic resonance imaging. *Clin Oral Investig* 2010; **14**: 169-176 [PMID: 19399539 DOI: 10.1007/s00784-009-0277-1]

82 **Gaudino C**, Cosgarea R, Heiland S, Csernus R, Beomonte Zobel B, Pham M, Kim TS, Bendszus M, Rohde S. MR-Imaging of teeth and periodontal apparatus: an experimental study comparing high-resolution MRI with MDCT and CBCT. *Eur Radiol* 2011; **21**: 2575-2583 [PMID: 21805369 DOI: 10.1007/s00330-011-2209-0]

83 **Tymofiyeva O**, Proff PC, Rottner K, Düring M, Jakob PM, Richter EJ. Diagnosis of dental abnormalities in children using 3-dimensional magnetic resonance imaging. *J Oral Maxillofac Surg* 2013; **71**: 1159-1169 [PMID: 23611603 DOI: 10.1016/j.joms.2013.02.014]

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**Table 1 Role of conebeam computed tomography for assessment of eruptive and morphological disturbances**

|  |  |  |  |
| --- | --- | --- | --- |
| **Ref.** | **Year** | **Eruptive or morphological disturbances** | **Tooth involved** |
| Nakajima *et al*[20] | 2005 | Impaction | Maxillary second bicuspid |
| Walker *et al*[12] | 2005 | Impaction | Canine |
| Siraci *et al*[45] | 2006 | Talon cusp | Facial and lingual surfaces of a supernumerary primary tooth |
| Maverna *et al*[34] | 2007 | Impaction | Maxillary canine |
| Andrade *et al*[49] | 2007 | Root dilaceration | Maxillary right central incisor |
| Liu *et al*[14] | 2007 | Supernumerary teeth | Complete dentition |
| Liu *et al*[32] | 2008 | Impaction | Maxillary canines |
| Haney *et al*[18] | 2010 | Impaction | Maxillary canine |
| Patel *et al*[59] | 2010 | Dens invaginatus | Mandibular lateral incisor |
| Song *et al*[73] | 2010 | Fusion | Right maxillary first molar and supernumerary tooth |
| Gurge *et al*[24] | 2011 | Impaction | Upper lateral incisor |
| Alqerban *et al*[33] | 2011 | Impaction | Maxillary canine |
| Kaneko *et al*[60] | 2011 | Dens invaginatus | Maxillary lateral incisor |
| Narayana *et al*[61] | 2012 | Dens invaginatus | Maxillary right lateral incisor |
| Vier-Pelisser *et al*[62] | 2012 | Dens invaginatus | Maxillary left lateral incisor |
| Kfir *et al*[63] | 2013 | Dens invaginatus | Right maxillary central incisor |
| Kato[64] | 2013 | Dens invaginatus | Maxillary lateral incisor |
| Cantin *et al*[65] | 2013 | Impaction | Mesiodens |
| Oenning *et al*[30] | 2014 | Impaction | Third molar |
| Mahesh *et al*[50] | 2014 | Root dilaceration | Permanent maxillary right central incisor |

**Table 2 Role of spiral computerized tomography in diagnosis of morphological disturbances of teeth**

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Ref.** | **Morphological disturbance** | **Tooth involved** |
| 2006 | Gopikrishna *et al*[79] | Unusual morphology of a single root and a single canal | Maxillary first molar |
| 2007 | Ballal *et al*[77] | Fusion | Mandibular second molar with a paramolar |
| 2009 | Metgud *et al*[78] | Single conical non bifurcated posterior root forms, taurodontism, dens invaginatus, labial lobes of the canines, pyramidal cusps of the premolars, dens evaginatii of the molar crowns, and localized reduction in tooth size | Entire dentition |

**Table 3 Magnetic Resonance Imaging in diagnosis of eruptive and morphological dental anomalies of permanent teeth**

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Ref.** | **Morphological disturbance** | **Tooth involved** |
| 2010 | Tymofiyeva *et al*[81] | Impaction | Entire dentition |
| 2013 | Tymofiyeva *et al*[83] | Mesiodens, gemination, dilacerations, transmigration, transposition | Entire dentition |