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EFFECTIVENESS OF CONE BEAM COMPUTED TOMOGRAPHY IN LOCALIZATION OF IMPACTED MAXILLARY CANINE AS COMPARED TO TRADITIONAL RADIOGRAPHS: A SYSTEMATIC REVIEW UPDATE

Dental Science

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ABSTRACT

Introduction: The exact location and early detection of impacted maxillary canines plays a very key role in the orthodontic treatment planning. The aim of the present review was to compare the diagnostic effectiveness and accuracy of CBCT with that of conventional radiography in the localization of impacted maxillary canines.

Method: Observational studies published between January 1, 2011, and December 1, 2017, were identified from PubMed-MEDLINE, the Cochrane library, IndMed, Google Scholar and major journals. Modified MINORS checklist was applied to assess the quality of studies.

Result: The preliminary screening consisted of 34 articles, of which 8 articles that met the inclusion and exclusion criteria were selected. All authors agreed that CBCT was more reliable and resulted in higher accuracy in localization of impacted maxillary canine. Out of 8 included studies 6 were moderate to high quality and only 2 studies were of low quality.

Conclusion: The use of CBCT is advantageous in treatment planning for impacted canines by providing accurate localization and facilitating understanding of the anatomic relationships between the impacted tooth and the adjacent roots. CBCT overall helped in increasing the confidence level of the clinician regarding the treatment planning.

KEYWORDS

Cone beam computed tomography, Traditional radiography, localization and Impacted maxillary canine.

INTRODUCTION

The cornerstone of the dental arches 'the canines' are one among the most frequently impacted teeth after the third molars.[1] The prevalence of impacted maxillary canines in various populations is reported to range from 0.9% to 3%. [2-7]In the Indian population it ranges from2.9% to 3.9%[8-9]. Maxillary canines are the most commonly impacted teeth, second only to third molars.[10]

The maxillary canine is located in a highly demanding area both aesthetically and functionally, so the exact location and early detection plays a very important role on the orthodontic treatment planning by influencing whether the canine should be aligned or removed.[11] Mismanagement and inaccurate diagnosis may cause complications during the development and eruption of an impacted canine.[12] Therefore, radiographic examinations play a crucial role in the diagnosis and treatment planning of impacted maxillary canines.

Traditional radiographs two dimensional (2D) have been employed for a long time for the three dimensional (3D) location of impacted maxillary canine. 2D radiographs demonstrate inherent drawbacks resulting from overlapping, blurring, magnification and distortion. To overcomes the limitations of conventional radiography the use of computed tomography (CT) was suggested. Computed tomography (CT) overcomes the limitations of conventional radiography by exact localization of impacted canines and an increased detection rate of root resorption. However, the use of CT is limited because of the relatively high radiation dose and high cost. With the advent of CBCT, many authors have suggested the routine use of this technology in diagnosis of impacted canines, as well as the spatial relationships with the neighboring structures. Compared with medical CT, CBCT is easy to use, with short acquisition scan times and high resolution, can be performed while patients are in the upright position, and is low-cost.[11-14]

An accurate determination of buccal-palatal and mesio-distal position of the impacted canine, the proximity of impacted canines to the roots of adjacent incisors and premolars, as well as the degree and severity of root resorption of adjacent teeth in 3 planes of space are the key features in treatment planning to move the canine in the arch and to decrease the risk of root resorption of adjacent teeth.

Systematic reviews are designed to locate, appraise, and synthesize the evidence from scientific studies to provide informative answers to scientific questions by including a comprehensive summary of the available evidence.[15]Thus, the aim of this systematic review is to evaluate whether three dimensional (3D) radiographic technique is more effective than the two dimensional (2D) radiographic technique in localization of impacted maxillary canines and assessment of root resorption of teeth adjacent to impacted canine.

MATERIALS AND METHOD

Focused question:

Are 3D radiographs (CBCT) more accurate in the localization of impacted maxillary canines and detection of presence and severity of root resorption of adjacent teeth than 2D radiographs?

Search strategy:

Two electronic databases were used to search for appropriate studies that would satisfy the study purpose: PubMed-MEDLINE,and the Cochrane library from 1st January , 2011, up to 31st December, 2017. Additional sources such as Google Scholar, IndMed and major journals were explored. Contact with authors was done for any unpublished studies. Detailed search strategy is shown in [Table 1].

Table 1: Search Strategy

Search strategy	Number of articles	Number of articles selected	Articles after duplicate removal
Cone Beam Computed Tomography AND Localization AND impacted maxillary canine	15	5	5
Cone Beam Computed Tomography OR CBCT OR CT) AND (impacted maxillary canine OR unerupted maxillary canine) AND traditional radiography	1	0	0
3D versus 2D radiographic imaging AND Impacted maxillary canine	2	2	0

impacted maxillary canine AND (panoramic radiography OR parallax technique OR conventional radiography)AND localization	5	3	0
impacted maxillary canine AND 3D imaging AND 2D imaging	10	8	5
Sub total	33	18	10
Other source	1	1	1
total	34	19	11

Inclusion criteria

1. Retrospective studies comparing the accuracy of Cone Beam Computed Tomography with that of conventional radiographs in localizing the impacted maxillary canines.
2. Studies that described diagnostic and/or therapeutic accuracy and efficacy of CBCT technique in the diagnosis of maxillary impacted canines.
3. Studies that have assessed the presence and severity of root resorption of teeth adjacent to the impacted maxillary canine using 2D and 3D imaging modalities.
4. Only papers in English were accepted.

Exclusion criteria

1. Reviews, case reports, abstracts, editorials, letters, and historical reviews were excluded.
2. Studies that have compared different radiographic exams done on four different subjects for the localization of impacted maxillary canines were not included.
3. Studies that have compared the efficacy of CBCT images in diagnosis of maxillary impacted canines with traditional radiographs not generated using traditional systems but obtained from CBCT data were not included.
4. Studies that were performed in in-vitro step up were excluded.

Screening and selection

The papers were independently scanned by two reviewers (KM and JR), first by the title and abstract. If the search keywords were present in the title and/ or the abstract, the papers were selected for full-text reading. Papers without abstracts but with titles suggesting that they were related to the objectives of this review were also selected to screen the full text for eligibility. After selection, full-text papers were read in detail by two reviewers (KM and JR). Those papers that fulfilled all of the selection criteria were processed for data extraction. Two reviewers (KM and JR) hand searched the reference lists of all selected studies for additional relevant articles. Disagreements between the two reviewers were resolved by discussion. If a disagreement persisted, the judgment of a third reviewer (SJ) was considered decisive.

Data extraction

From the collection of papers that met the inclusion criteria, data were extracted with respect to the mode of localization of Impacted maxillary canines and the accuracy of localization with 3D radiographic and 2D radiographic technique was assessed.

Analysis of the study quality

The quality of the slected 8 articles was analysied using modified MINOR's checklist[16] [Table 2]. The items are scored 0 (not reported), 1 (reported but inadequate) or 2 (reported and adequate). According to the total scores, the studies were catergorised into low quality study(total score ≤15), moderate quality study(total score =16- 18) and high quality study(total score= 19-20).

RESULTS

Search and selection results

The PubMed-MEDLINE, Cochrane library, and other sources identified 34 unique records which were screened by titles and abstracts [Figure 1]. After full-text reading, 15 records were excluded. This exclusion resulted in 19 full-text articles. The remaining 8 studies[10-14,17-19] that fulfilled the selection criteria were processed for data extraction. Additional hand searching of the reference lists of the selected studies yielded no additional records.[Figure 1] An overview of the selected studies[reference] and their characteristics are presented in [Tables 3]

Localization of impacted canine

The determination of canine location significantly differed between the 2D radiographs and CBCT systems (3D), with CBCT having higher accuracy in localizing. CBCT images provide applicable diagnostic information for canine location in the sagittal, axial, and

Table 2 : Modified MINORS checklist for assessment of quality of study

No:	Methodological items	Botticelli S. et. Al [13] (2011)	Alqerban A [12] (2012)	Jung YH et. Al [10] (2012)	Alqerban A [14] (2013)	Lai C S [17](2014)	Alqerban A [11](2014)	Dalessandri D [18](2014)	Alqerban A [19](2016)
1	A clearly stated aim:	2	2	1	2	2	2	2	1
2	Inclusion of consecutive patients	2	1	2	2	2	2	1	2
3	Prospective collection of data	2	2	2	1	2	2	1	2
4	Endpoints appropriate to the aim of the study	2	2	0	2	2	2	1	2
5	Unbiased assessment of the study endpoint	1	2	2	1	2	1	2	1
6	Prospective calculation of the study size	1	2	1	1	2	1	1	1
7	An adequate criteria assessment	2	2	1	2	2	2	1	2
8	Contemporary groups	2	2	1	2	2	2	2	2
9	Baseline equivalence of groups	2	2	2	2	2	2	2	2
10	Adequate statistical analyses	2	2	1	1	2	2	2	2
	total	18	19	13	16	20	18	15	18

Interpretation: ≤15= low quality studies, 16-18=moderate quality study ,19-20= high quality study
The items are scored 0 (not reported), 1 (reported but inadequate) or 2 (reported and adequate).

Table 3: Data extraction sheet

Author Year of publication	Sample size and characteristic(sex and mean age)	No of impacted canines	2D imaging modality	3D imaging modality	Criteria's assessed	Results	Conclusion	Quality of study *

Botticelli S et. Al[13] 2011	27 [17 F & 10 M] Mean age: 11.8 years	39	Panoramic, lateral head film & periapical radiographs [Digora Optime System, Finland]	CBCT [NewTom 3G scanner,Italy]	localization of IMC, RR, treatment choice, difficulty of case & quality of image	The increased precision in the localization of the IMC (68%)and detection of RR (82%) with CBCT	statistically significant difference seen in 2D radiographs and 3D radiographs in localization and detection of RR that led to a difference in diagnosis and treatment planning towards a more clinically orientated approach using 3D radiography.	Moderate quality
Alqerban A et. Al[12] 2011	60 [37 F & 23 M] mean age 13.2 years	89	Panoramic radiograph [Cranex Tome® (Soredex)]	CBCT 3D [Accuitomo-XYZ, Scanora]	Localization of IMC, presence & severity of RR	CBCT was more reliable in localization and resulted in higher measurement accuracy.CBCT increases the perceptibility of detecting RR	highly significant difference seen beetween 2D and 3D imaging , CBCT more accurate for localization and detetction of severity of RR of adjacent teeth	High quality
Jung Y H et al [10] 2012	63 [35 F & 28 M] mean age 18.4 years	73	Panoramic radiograph [Proline XC,Finland]	CBCT [DCT pro, korea]	labiopalatal position of canine & RR of incisor	1.Labially IMCs were more frequent in Sectors 1, 2 and 3, mid-alveolus IMCs were most frequent in Sector 4 and palatally IMCs were most frequent in Sector 5.	sector location on panoramic radiography could be used to predict the labiopalatal position of IMCs. CBCT imaging was significantly better than that of panoramic radiography for determining RR	Low quality
Alqerban A et. Al [14] 2013	32 [19 F & 13 M] mean age 25 years	39	Panoramic radiograph [Veraviewepocs 2D, Japan]	CBCT [Accuitomo-XYZ]	localization of IMC,RR and surgical planning	type of treatment chosen, surgical technique did not differ in 2D or 3D, but treatment planning, diagnosis of canine location, contact with adjacent teeth and presence of RR greatly differed between two techniques , 3D being superior	statistically significant difference was found in localization of canine and detection of RR with CBCT being more accurate. Surgical treatment planning of IMC was not significantly different between panoramic and CBCT images	Moderate quality
Lai CS et. al [17] 2014	60 [42 F & 18 M] mean age 17.3 years	72	Panoramic radiographs [different machines]	CBCT [accuitom-XYZ]	Localization of IMC, presence & severity of RR	labiopalatal location of the impacted maxillary canine, agreement between 2D and 3D data (P value = 0.292) was rather low or limited.CBCT showed more clear visualization of RR	The labiopalatal location of the IMC was the most frequent reason justifying further 3D radiographic imaging,Not all cases CBCT is required, only when exact location and degree of resorption is not clear.	High quality
Dalessandri D et al[18] 2014	90	105	Panoramic radiograph [Orthophos XGplus Sirona digital machine]	CBCT [NewTom 3G scanner,Italy]	localization of IMC using a 2D index and a 3D index	CBCT images are of fundamental importance in recognizing the presence of adjacent teeth RR3D index was more accurate in locating the IMC than 2D index	2D indexes for predicting IMC treatment duration and difficulty sometimes are discordant; a 3D index like the KPG index could be useful in solving these conflicts	Low quality
Alqerban A et al [11] 2014	40 [26F & 14M] mean age 12.5 years	63	Panoramic radiograph [Veraviewepocs 2D, Japan]	CBCT [accuitom-XYZ]	Localization of IMC, presence & severity of RR and treatment planning	location of canine and RR was more accurately assessed with CBCT	CBCT sigificantly increased the perceptibility of canine and RR.. Only when 2D records are insufficient then 3D imaging is advised. 3D images are better in diagnostic parameters for all variables	Moderate quality
Alqerban A et al [19] 2016	306[188F & 118M] mean age 14.7 years	406	Panoramic radiograph [Canex-TOME and Veraviewepocs 2D, Japan]	CBCT 3D [Accuitomo-XYZ, Scanora]	localization of IMC and RR	Prediction of RR based on panoramic radiographs is difficult and additional CBCT examination is required	CBCT showed more accurate location of IMC and RR.	Moderate quality

IMC=Impacted Maxillary Canine, RR= Root Resorption , F=Female, M=Male
*Modified MINORS checklist

coronal planes without overlap. In this review it was found that 2D radiography provide an overview of the location of the impacted canine and possible treatment options but were not a reliable method for accurately locating of impacted canines position as well as the severity of root resorption.. All the studies agreed that CBCT was more accurate in determination of buccal-palatal and mesio-distal position of the impacted canine, the proximity of impacted canines to the roots of adjacent incisors and premolars, as well as the degree and severity of root resorption of adjacent teeth

Root resorption:

The root resorptions detected in the lateral incisor, central incisors and premolars was evaluated. Compared with panoramic radiography, lateral incisor root resorption cavities were more distinguishable using CBCT. Greater agreement between all the observers of the included articles for all variables was achieved when using CBCT. The results show that the proportion of agreement was high for the assessment of CBCT images. Lateral incisor showed resorption in most number of cases followed by the central incisor and the the premolars.. Comparative studies have found that conventional panoramic radiography had a low reliability for diagnosing incisor root resorption associated with impacted canines compared with CBCT.

Quality of studies:

Out of the 8 studies included in this review 2 studies were of high quality, 4 studies were moderate quality and 2 studies were of low quality. Therefore an overall quality of the included articles was of good quality. [Table 2]

While comparing the accuracy of 2D radiographs with that of 3D

radiographs in localization of impacted canine as well as root resorption, all studies showed a statistically significant difference with 3D radiographs having higher accuracy. ($p<0.005$)

The treatment planning,[11,13] treatment duration and surgical technique[14] used showed no statistically significant difference between the 2D imaging modality and 3D imaging modality.

DISCUSSION

Impacted maxillary canines require longer treatment duration so their precise location plays a very crucial role in diagnosis and treatment planning. This systematic review compared the diagnostic effectiveness of CBCT vs conventional radiograph in accurately locating impacted maxillary canine. With respect to previous review by Giulia Rossini et. Al,[21] this review is an update with recent articles evaluated. A total of 8 articles were included. On analyzing the quality of the studies for 8 articles, 6 showed moderate to high quality and only 2 articles showed low quality. The primary objective of this review was to assess the location of impacted canine and the presence and severity of root resorption of adjacent teeth because they have been discussed as having a an important role in the decision-making process for the treatment of impacted maxillary canines. The secondary objectives included the difference in treatment planning and surgical techniques used between 2D and 3D radiographic techniques.

The location of impacted maxillary canines in labiopalatal, mesiodistal and vertical plane demonstrated statistically significant differences with respect to accurately localizing impacted canine in all three planes with CBCT showing higher accuracy in localization. This was because CBCT images provide applicable diagnostic information for canine location in the sagittal, axial, and coronal planes without overlap. This is in agreement with a recent review by Rossini et. Al [21]who found 2D images were not a reliable method for localization of impacted canines. Vertical level of impacted maxillary canine also influenced the treatment duration. Vertical level differed significantly in 2D and 3D images with 2D images showing tendency towards higher placement with respect to occlusal plane. This is because the central ray of panoramic radiograph is located slightly negative angulation of -7 degrees to the anterior teeth.[10,13] Comparison of the linear and angular measurements made on panoramic radiograph and CBCT images showed that panoramic radiographs were less reliable and resulted in lower measurement accuracy and less agreement between observers. This may be because the conventional images generated with 2D film often suffer from magnification, distortion, and superimposition.[11,12,14] In contrast to this, several authors have suggested that the linear measurement is a reliable method for panoramic radiographs, considering the magnification factors and correct patient position.[3,4,22-24]

Results of 2 articles that assessed the accuracy of localization of impacted maxillary canines using an in vitro laboratory setup of impacted canine were in accordance with this review stating that CBCT is more accurate than either horizontal or vertical parallax or panoramic radiograph for the localization of ectopic maxillary canine teeth.[25,26]

Root resorption of adjacent teeth is more prevalent and more frequently related to impacted canines. Root resorption has shown significant differences among imaging modalities. All authors agreed that 2D images tend to underestimate the presence and extent of root resorption, thus demonstrating superiority of 3D imaging early diagnosis specially in early or mild resorption cases. Thus root resorption cannot be judged from conventional projection radiograph alone, additional 3D imaging is required.[10,12,17] Four studies[11,12,17,19] assessed the severity of root resorption using the classification proposed by Ericson and Kurol, 2002[20]:1. no resorption, with intact root surfaces; 2. slight resorption, extending up to half of the dentin thickness to the pulp; 3. moderate resorption, midway to the pulp or more, with the pulp lining unbroken; and 4. severe resorption, with the pulp exposed. Not only the detection of presence root resorption is important but the severity of root resorption is also advantageous in planning the treatment protocol. The severity of root resorption was higher in lateral incisor because of the eruptive path of the canine is generally along the distal root surface of the lateral incisor. In accordance with previous studies, in this review also the incidence of resorption was noted higher with lateral incisor followed by the central incisor and then the premolars.[1,3,4,28]

The assessment of difficulty of case differed significantly in the two imaging modalities with 3D rendering treatment more difficult due to more accurate localization if impacted canine. 2D examination led to more observational – interceptive treatment approach while 3D imaging led to more active treatment approach.[11,13,14]

Surgical treatment planning had no statistical difference between 2D and 3D imaging. This may be due to the fact that type of surgery to be performed is generally the treating surgeons choice. Although the direction of orthodontic traction after surgical exposure differed between CBCT and panoramic radiograph. CBCT helped better in planning the direction of traction.[11] It was found that that in 65.7% times future use of CBCT was needed to know the accurate position on impacted maxillary canine.[17]

The use of CBCT is advantageous in treatment planning for impacted canines by providing accurate localization and facilitating understanding of the anatomic relationships between the impacted tooth and the adjacent roots, such as the presence of abnormalities, dilacerations, root resorption of the adjacent incisors, and mesiodistal root angulation. 3D images allow clinicians to obtain the accurate knowledge necessary for optimal confidence in treatment planning. CBCT overall helped in increasing the confidence level of the clinician regarding the treatment planning. However, the radiation dose of CBCT is 2–4 times the effective dose of the panoramic radiograph, which is between 4.7 and 14.9 mSv.[27] Therefore , routine replacement of panoramic radiographs with CBCT in localizing impacted canines should be considered with great care especially while treating children.

Limitations of this review:

Use of different CBCT machines with different FOV may have any effect on the accuracy of localization. If the FOV of the CBCT is smaller, the extracted images will have less of the information needed for orthodontic diagnosis

Implication for future research:

Further studies on correlation of radiographic findings with that of level surgical difficulty and difficulty of orthodontic alignment of impacted maxillary canine must be done. Quantification of surgical difficulty and orthodontic treatment in aligning impacted maxillary canine is required. A reduction in the radiation dose is desirable, thus focus on developing CBCT with low radiation dose is needed. Specific indications for obtaining a 3D radiograph must be investigated.

CONCLUSION

The meticulous investigation of this review concludes that 3D radiographs shows higher diagnostic accuracy for localization of impacted maxillary canine and root resorption of adjacent teeth than conventional radiograph. This review suggests that CBCT was more reliable and resulted in higher measurement accuracy. Type of treatment chosen, surgical technique and prediction of complications did not differ significantly in 2D or 3D radiographic imaging techniques. Although CBCT is more accurate than conventional radiograph in locating impacted maxillary canine, in all cases CBCT is not required, only when exact location and degree of resorption is not clear CBCT is advised.

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