Review Article

ROLE OF CONE BEAM COMPUTED TOMOGRAPHY IN ENDODONTICS: A SYSTEMATIC REVIEW

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ABSTRACT

The objective of this study was to assess the role of Cone Beam Computed tomography in the field of endodontics. In the last 30 years, digital imaging, as opposed to analogue imaging, has been developed and introduced. This has facilitated the development of advanced x ray imaging methods, notably computed tomography (CT). Recently, cone beam computed tomography (CBCT) has been developed that brings three dimensional imaging into the dental surgery and there have been several reports in the literature of using CBCT for endodontic imaging. CBCT does, however, have some drawbacks. First among these is the radiation dose which is higher than periapical radiographs. Its cost is high and availability is limited. In rational use of imaging, it is fundamental that benefits must outweigh risks. There is, therefore a need to develop evidence based guidelines for when CBCT should be considered in endodontic imaging. At present intra oral radiograph is the technique of choice for diagnosing, managing and assessing endodontic disease but it is well established that intra oral radiography is of limited use for detecting some critical endodontic problems. The lack of three dimensional information and masking of areas of interest by overlying anatomy is of particular relevance in endodontics. Cone beam computed tomography scans provides high quality accurate three dimensional images of Dentomaxillofacial region and have replaced conventional computed tomography because of its reduced radiation dose. A systematic review was conducted in the University of Manchester. The literature related to the importance of Cone Beam Computed Tomography in endodontics was searched in several bibliographic databases such as Medline, Embase and Cocharane database of systematic reviews from 2000 to May 2008. This study showed an increasing trend of seeking Cone beam computed tomography in endodontic treatment however to recommend routine CBCT for periapical diagnosis is inappropriate with such limited evidence and an almost certain lack of cost-effectiveness.

Key words: Dental radiography, Endodontic, Cone beam computed tomography.

INTRODUCTION

Radiology is important for the diagnostic assessment of dental patient. A good quality pre-operative radiograph will give valuable additional information as clinically observed signs and symptoms alone cannot give enough information to formulate diagnosis[1]. According to Niemiec[2] the success rate of endodontically treated teeth depends significantly on the adequacy of both pre and post operative radiographs. Walton and Torabinejad[3] reported that dental radiographs acts as diagnostic tool in the different mechanistic stages of endodontic treatment however it is important that X-rays should only be used to answer specific questions and defined diagnostic tasks, based upon the patient's actual needs.

At present, different dental radiographic modalities are used by dentists, of which bitewing, occlusal, periapical and panoramic are the most important. The invention of panoramic radiography provided a convenient way of imaging the entire dentition in one examination, but provides little fine detail of relevance to everyday dental tasks[4]. Consequently, bitewing and periapical radiographs remain the staple imaging tool in dentistry.

Bender and Seltzer[5] pointed out that superimposition of structures presents problems in image interpretation. Invention of X-ray computed axial to-

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mography (CT) was revolutionary in medical imaging in eliminating this. But high doses of radiation and unnecessary exposing larger areas were its limitation. Cone Beam Computed Tomography (CBCT) uses a cone shaped beam of radiation to acquire a volume in a single 360 degree rotation similar to panoramic radiotherapy. The CBCT scanner utilizes two dimensional detectors (either selenium flat panel detectors or image intensifiers). A single rotation of the gantry produces a scan of the head, in contrast with conventional CT scanners in which multiple slices must be stacked to obtain a complete image. A single 360 degree scan gathers the data for image reconstruction of a cylinder with heights and diameters that vary according to the manufacturer. Half or 180 degree scans can also be used with some CBCT systems, giving a lower radiation dose, although image quality is less. The exposure time of CBCT scanners is typically less than 20 seconds and reconstruction of the image takes less than 2 minutes[6].

Cone beam computed tomography or digital volume tomography utilizes an extra oral imaging scanner which was developed in the late 1990's to produce three dimensional scans of the maxillofacial region at considerably lower radiation than conventional computed tomography(CT)[4]. The x- ray beam of CBCT captures a cylindrical or spherical volume of data, described as the field of view. CBCT scanner use simpler, less complicated and therefore less expensive hardware than CT scanners and use powerful, but low cost computers[6].

There are two types of CBCT, large volume CBCT Scanners have a large field of view allowing the entire maxilla or mandible to be scanned, whereas limited CBCT scanners have a smaller field of 3-4 cm[3,7]. The Food and Drug Administration (FDA) approved the first CBCT unit for dental use in the United States in March 8, 2001 – the New Tom DVT 9000(Quantitative Radiology Verona, Italy). There are numbers of factors that will affect the radiation dose produced by CBCT system: the imaging parameters used, pulsed beam versus continuous beam, amount, type and shape of the beam filtration and limitation of the size of the field of the view[8].

This study has been carried out with the aim to conduct a systematic review of the role of CBCT in the field of endodontics.

METHODOLOGY

Critical appraisal

Poor quality studies were allocated to an appropriate weighting to give a more balanced assessment of the state of current knowledge. An appraisal sheet was developed by adapting ideas obtained from the National Health Service Public Health Resource Unit (www.phru.nhs.uk). All the papers were graded using the criteria listed in Table 1 .This table shows those features of research studies that indicate high quality e.g. a true reference standard (gold standard), calculation of sensitivity and specificity etc.

Interpreting the Findings

Findings were interpreted after critical appraisal and pooling of the results. Importance of our findings in relation to clinical practice was also considered. In addition, it has been assessed what implication our results may have for future research. In particular, we identified any questions that were left unanswered.

In this study 36 publications[1-36] were identified and 14 studies were excluded leaving 22[1-22] papers for formal critical appraisal.

Several bibliographic databases such as Embase, Medline and Cocharane database of systematic reviews were searched, limiting the search in terms of date of publication and English based studies. All those studies which were not related to the topic were excluded. The data extraction sheet was developed, and all included papers were graded on the basis of their quality of study as mentioned in table 1. One paper was graded in category of Grade A, three papers of Grade B and nine papers of grade C, which shows that most of the papers were of low scientific quality, in many cases representing personal opinions.

The study of Lofthag- Hansen et al[1] was graded as A because this study satisfied the criterion in having a Gold standard and low evidence of bias. It also provided a useful recommendation for clinical practice. In addition, it was a human study which had good methodology and sample size. The three studies which were given Grade B had not only good methodology but also had proper criteria for inclusion and exclusion; in addition, some also used sensitivity and specificity tests but they carried lower level of evidence in comparison to Lofthang study. The nine papers which

had grade D were mostly opinion papers with no research and no evidence-based recommendation.

DISCUSSION

A systematic review is defined by the Cochrane 'A review of a clearly formulated question that uses systematic and explicit methods to identify, select and critically appraise relevant research, and to collect and analyze data from the studies that are included in the review Statistical methods may or may not be used to analyze and summarize the results of the included studies[9]'.

It involves specified and appropriate methods to identify, appraise, and summarize studies addressing a defined question. It can, but need not, involve meta-analysis. Meta-analysis is a statistical technique that summarizes the results of several studies in a single weighted estimate, in which more weight is given to results of studies with more events and sometimes to studies of higher quality. Ideally, a meta-analysis should be performed as part of a systematic review while review is an article that summarizes several studies that address a given question or objective and do not explicitly explain how the reviewers searched, selected and appraised the quality of studies. In contrast, systematic review includes a comprehensive, exhaustive search for primary studies on a focused clinical question, selection of studies using clear and reproducible eligibility criteria, critical appraisal of studies for quality and synthesis of results according to a pre-determined and explicit method[10].

According to Morgan[11], systematic reviews are important because "through critical exploration, evaluation and synthesis, the systematic review separates the insignificant, unsound or redundant dead wood in the literature from the salient and critical studies that are worthy of reflection". The unique advantage of systematic review is increased power and precision in estimating effects and risks. In addition it also limits the bias and improves the reliability and accuracy of recommendations.

CBCT is an emerging technology which gives clinically relevant information to the clinician that cannot be achieved from conventional radiography[12]. This imaging tool has numerous applications in the field of dentistry such as implant treatment planning, orthodontic evaluation of growth and development and endodontic treatment[13].

The results given (in Table 2) clearly showed that there is very limited proof and evidence about the role of CBCT in endodontics. The only paper which showed results with a high level of evidence was produced by Lofthag-Hansen[1], which compared the intra-oral radiograph with CBCT in the diagnosis of periapical pathosis in human subjects. They found that CBCT provided additional clinically relevant informa-

TABLE 1: GRADING OF PAPERS

Grade	Description
A	High quality systematic reviews having true gold standard with lowest possible bias. Meta-analysis having a proper recommendation statistical analysis and involve sensitivity and specificity tests.
B	Well conducted studies with no true gold standard and have peer leader opinion with moderate risk of bias.
C	Non-Analytical studies e.g. case series , cross-sectional surveys having no gold standard and have high risk of bias (probably biased towards cases)
D	Non-Systematic reviews having very small case reports and may involve opinion papers

TABLE 2: RESULTS OF SYSTEMATIC REVIEW

No	AUTHOR		GRADE
1	Lofthag-Hansen et al[1]	(2007)	A
2	Kalathingal et al [22]	(2007)	B
3	Stavropoulos et al[14]	(2006)	B
4	Hashimoto et al[13]	(2006)	B
5	Akdeniz et al[25]	(2005)	C
6	James et al[26]	(2006)	C
7	Ryan et al[27]	(2008)	C
8	Hashimoto et al[19]	(2003)	C
9	Zhang et al[28]	(2006)	C
10	Taylor et al[12]	(2007)	C
11	Simon[29]	(2006)	C
12	Cohenca et al(Part 1)[15]	(2006)	C
13	Nakata et al[30]	(2006)	C
14	Cohenca et al(Part 2)[31]	(2006)	D
15	Scarfe et al[32]	(2006)	D
16	Patel et al[33]	(2007)	D
17	Tsurumachi et al[34]	(2007)	D
18	Estrela et al[35]	(2008)	D
19	Nair et al[36]	(2007)	D
20	Young[20]	(2007)	D
21	Sogur[35]	(2007)	D
22	Sukovic[36]	(2003)	D

tion not found in the periapical radiograph in 70% of cases. Stavropoulos[14] showed that CBCT has higher sensitivity, positive predictive value and diagnostic accuracy than intra-oral radiography when evaluating the presence of artificially created bone-defects. Clearly, therefore, CBCT may allow the clinician to detect a lesion not readily seen with intra-oral radiography. In situations where patients have poorly localized symptoms associated with an untreated or previously root-filled tooth and clinical and periapical radiographic examination showed no evidence of disease, CBCT may be indicated to detect the presence of undiagnosed periapical disease[15]. Thus it helps to determine the nature of peri-radicular lesion[16]. Recently, Estrela[17] presented a paper comparing the diagnostic accuracy of periapical and panoramic radiography for diagnosis of periapical disease. It is notable that they chose CBCT as their reference standard; such a strategy is inappropriate as CBCT is not a "gold standard".

In addition, CBCT may also provide information about the number of roots and morphology of the root canal system. Recently CBCT has been used for the management of external cervical resorption lesions[18]. Hashimoto[13] compared the image quality of CBCT with medical CT. He found that for both tooth and bone, CBCT produced higher resolution of images. In another study in 2003[19], Hashimoto concluded that the radiation dose of CBCT is equal to 2-3 intra-oral radiographs and that it provides "more reliable information" for oral diagnostic purposes. It is important, however, to remember that results such as these are specific to the make and model of CBCT equipment used in the study and such statements must be viewed with caution.

In root canal treatment there are some cases where a periapical radiograph does not provide adequate information on pathologic conditions such as perforation, resorption etc. Perforation plays an important role in the success rate of root canal treatment. Young[20] in 2007 demonstrated the application of CBCT in the diagnosis of iatrogenic root perforation. This study concluded that better prognosis can be achieved if CBCT is used.

CBCT technology provides the clinician with the ability to observe the region of interest in three different planes and thus acquire 3-D information. It gives more accurate measurement of root angulation compared with panoramic images[21].

Apical periodontitis is a consequence of root canal system infection which may produce periapical bone changes and resorption. It is concluded that CBCT accurately identified apical periodontitis compared with panoramic and periapical radiograph[22].

CONCLUSION

It is reasonable to suggest on the basis of this evidence that CBCT technology should not replace conventional radiography, but rather serve as an adjunct in acquiring additional diagnostic information in selected cases where conventional radiography has not provided sufficient diagnostic information. Cone beam computed tomography is, however, impractical for dentists to use because of cost and excessive radiation dose for minor dental applications.

LIMITATION

The limitations of this study were small time period as papers were included up to May 2008, papers which will be published after this date may change the results. In addition to that, different manufacturers will produce different CBCT modalities and modifications to existing equipment in the future, also threatening the validity of the results. We also limited the study by limiting the search to English based papers.

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