Evidence supporting the use of cone–beam computed tomography in orthodontics

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In the last two decades, two-dimensional (2-D) images, such as facial photographs or traditional frontal and lateral cephalometric radiographs, which have been used since the 1930s,[1,2] have been replaced in part by three-dimensional (3-D) photographs and 3-D cone-beam computed tomography (CBCT) scan images.[3-5] The number of articles regarding CBCT applications has increased since its introduction into orthodontics. We have noticed that the available literature regarding CBCT in databases such as PubMed grows weekly. This increase may have been fueled in part by misinformation regarding its safety and efficacy. CBCT is an image acquisition technique that uses a cone-shaped x-ray beam. Similar to an orthopantogram, the x-ray beam is aimed at a detector. A pair of source-detector devices rotates around the patient to produce a series of 2-D images. These images are reconstructed on a computer to form a 3-D data set. Dedicated CBCT scanners for the oral and maxillofacial region were pioneered in the late 1990s.[6] Interest in this imaging technique for use in the oral and maxillofacial region has increased.

Investigators of previous studies that applied CBCT and authors of narrative reviews that discussed the possibilities and limitations of

ABSTRACT

Background. The authors conducted a systematic review of cone-beam computed tomography (CBCT) applications in orthodontics and evaluated the level of evidence to determine whether the use of CBCT is justified in orthodontics.

Types of Studies Reviewed. The authors identified articles by searching the Cochrane Library, PubMed, MEDLINE, Embase, Scopus and Cumulative Index to Nursing and Allied Health Literature databases. They searched the articles' reference lists manually for additional articles and had no language limitations. They did not search the gray literature. Inclusion criteria were CBCT use in orthodontics and that the participants be human. The lowest level of evidence accepted for inclusion was a case series with five or more participants. The authors evaluated the studies' methodological quality according to 13 criteria related to study design, measurements and statistical analysis.

Results. The authors identified 550 articles, and 50 met the inclusion criteria. Study topics included temporary anchorage devices, cephalometry, combined orthodontic and surgical treatment, airway measurements, root resorption and tooth impactions, and cleft lip and palate. The methodological quality averaged 53 percent (range, 15-77 percent) of the maximum score.

Clinical Implications. The authors found no high-quality evidence regarding the benefits of CBCT use in orthodontics. Limited evidence shows that CBCT offers better diagnostic potential, leads to better treatment planning or results in better treatment outcome than do conventional imaging modalities. Only the results of studies on airway diagnostics provided sound scientific data suggesting that CBCT use has added value. The additional radiation exposure should be weighed against possible benefits of CBCT, which have not been supported in the literature. In future studies, investigators should evaluate the effects of CBCT on treatment procedures, progression and outcome quantitatively.

Key Words. Review; cone-beam computed tomography; three-dimensional imaging; orthodontics; maxillofacial.

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CBCT[7-9] have described the potential for the use of CBCT in orthodontics. For example, CBCT can help in determining the best temporary anchorage device (TAD) location, in the planning for and outcomes evaluation of combined orthodontic and surgical treatment, and in the diagnosing of and treatment planning for complex cases such as those involving cleft lip and palate (CLP). CBCT also can provide 3-D cephalometry, 3-D evaluations of the temporomandibular joint and 3-D information regarding the locations of impacted teeth. Manufacturers of CBCT devices have advertised the benefits of using 3-D technology, but these claims have not been supported adequately. To our knowledge, no investigators have conducted a systematic review whose results support the use of CBCT in orthodontics. We conducted a systematic review to assess the use of CBCT in orthodontics and to determine what level of evidence is available to support the use of CBCT in orthodontic diagnosis and treatment planning.

METHODS

Information sources. To identify publications, we conducted an electronic database search. We searched the reference lists of articles manually for additional literature. We set no language limitations, and we did not attempt to explore the gray literature.

We searched the following databases:

- PubMed (from Jan. 1, 1966, to March 15, 2010);
- MEDLINE (from Jan. 1, 1966, to March 15, 2010);
- Embase Excerpta Medica (from Jan. 1, 1980, to March 15, 2010);
- Scopus (from Jan. 1, 1996, to March 15, 2010);
- Cumulative Index to Nursing and Allied Health Literature (CINAHL) (from Jan. 1, 1982, to March 15, 2010);
- Cochrane Library (from Jan. 1, 1993, to March 15, 2010).

Search strategy. We developed the search strategy and selected the databases with the help of a senior librarian who specialized in health sciences.

The search strategy focused on the terms "Cone Beam CT" and "Orthodontics." We used both free text words in the title and abstract (TIAB) and Medical Subject Headings (MeSH) terms. For PubMed and the Cochrane Library, the following search sequence we selected was "Orthodontics"[MeSH] OR "Orthodontic*" AND "Cone-Beam Computed Tomography"[MeSH] OR "cone beam" OR "computed tomography"[TIAB] OR "volume ct"[TIAB] OR "cbct"[TIAB] OR "volumetric ct"[TIAB].

For MEDLINE, the search sequence we selected was "Orthodontics" or Orthodontic* and "Cone-Beam Computed Tomography" or "cone beam" or "computed tomography" or "volume ct" or "cbct" or "volumetric ct."

For Embase, the search sequence we selected was "Orthodontics" or Orthodontic* and "Cone-Beam Computed Tomography" or "cone beam" or "computed tomography" or "volume ct" or "cbct" or "volumetric ct."

For Scopus, the search sequence we selected was "Cone Beam" and "orthodontics."

For CINAHL, the search sequence we selected was "Orthodontics" or "Orthodontic" or "Orthodontics+"[MeSH heading (mh)] And "Computed Tomography" or "Tomography, X-Ray Computed+"[mh] or "volume ct" or "cbct" or "volumetric ct" or "Cone-Beam Computed Tomography" or "cone beam" or "computed tomography."

Study selection. In the first step of the screening process, two observers (O.J.C.V., A.M.K.-J.) independently screened the retrieved records on the basis of TIAB. They included articles that involved a study regarding CBCT requested for orthodontic purposes and articles that involved human participants. The lowest level of evidence accepted for inclusion was a case series with a sample size of five or more. They excluded reviews, letters and case reports from the study. They classified articles as included, excluded or unclear after reviewing only the abstract. The observers resolved any differences regarding which articles to include or exclude by achieving consensus. In the second step of the screening process, they obtained the full articles for those articles classified as included or unclear because the title or abstract did not present enough relevant information. Any articles that might have been of interest for our review underwent the first and second steps of the screening.

Grading of methodological quality. The observers (O.J.C.V., M.A.R.K.) independently assessed the methodological quality of the selected articles according to a scoring system

ABBREVIATION KEY. 2-D: Two-dimensional. **3-D:** Three-dimensional. **CBCT:** Cone-beam computed tomography. **CINAHL:** Cumulative Index to Nursing and Allied Health Literature. **CLP:** Cleft lip and palate. **CT:** Computed tomography. **ECRR:** European Committee on Radiation Risk. **ICRP:** International Commission on Radiological Protection. **MeSH:** Medical Subject Headings. **mh:** MeSH heading. **TAD:** Temporary anchorage device. **TIAB:** Title and abstract.