CBCT applications in dental practice: A literature review

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CBCT is largely used in orthodontic surgery planning when facial orthognathic surgery is indicated that requires detailed visualisation of the interocclusal relationship in order to augment the 3-D virtual skull model with a detailed dental surface. With the aid of advanced software, CBCT facilitates the visualisation of soft tissue to allow for control of post-treatment aesthetics, for example in cheek palate cases to evaluate lip and palate bone depressions.14–16

Table I

<table>
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<tr>
<th>Specialty</th>
<th>Number of articles</th>
<th>in %</th>
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<tr>
<td>Oral and maxillofacial surgery</td>
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<td>Endodontics</td>
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<tr>
<td>Implantology</td>
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<td>General dentistry</td>
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<td>Temporomandibular joint disorder</td>
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<td>Periodontics</td>
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<td>3.73</td>
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Clinical and scientific literature discussing CBCT imaging in dental clinical applications was reviewed. A MEDLINE (PubMed) search from 1 January 1994 to 15 July 2010 was conducted. Cone-beam computed tomography in dentistry was used as key phrase to extend the search to all the various dental disciplines. The search revealed 549 papers that were screened in detail. Owing to a lack of relevance to the subject, 466 papers were excluded. Thus, the systematic review consisted of 154 clinically relevant papers, which were analysed and categorised (Table I).

Analysis

Oral and maxillofacial surgery

CBCT enables the analysis of jaw pathology,1–3 the assessment of impacted teeth (Fig. 1), super-numerary teeth and their relation to vital structures,4–21 the changes in the cortical and trabecular bone related to bisphosphonate-associated osteonecrosis of the jaw (jaw-2),22–24 the assessment of bone grafts,25 it is also helpful in analysing and assessing paranasal sinuses46–48 and obstructive sleep apnoea.49–50

The images are collected from many diff-ferent 2-D slices, the system has proven its superiority in overcoming superimpositions and calculating surface distances.51–53 This advantage made it the technique of choice in mid-face fracture cases,54–56 orbital fracture assessment and management57 and for inter-operative visualisation of the facial bones after fracture.58–60 Since it is not a magnetic resonance technique, it is the best option for intra-operative navigation during procedures, including gun-shot wounds.61–64

CBCT is largely used in orthognathic surgery planning when facial orthognathic surgery is indicated that requires detailed visualisation of the interocclusal relationship in order to augment the 3-D virtual skull model with a detailed dental surface. With the aid of advanced software, CBCT facilitates the visualisation of soft tissue to allow for control of post-treatment aesthetics, for example in cheek palate cases to evaluate lip and palate bone depressions.14–16

Research is underway to assess its ability to detect salivary gland defects.62 Honda et al.63 describe a clinical case in which the time needed to complete a tooth auto-transplant case was significantly shortened owing to the application of CBCT.

Endodontics

CBCT is a very useful tool in diagnosing apical lesions (Figs. 2a & b).64–66 A number of studies have demonstrated its ability to enable a differentiation of apical lesions by measuring the density from the contrasted images of these lesions, whether the lesion is an apical granuloma or an apical cyst (Figs. 3a & b).67–70 Cotton et al.68 used CBCT as a tool to assess whether the lesion was endodontic or non-endodontic origin.

CBCT also demonstrated superiority to 2-D radiographs in detecting fractured roots. Vertical and horizontal root fracture detection is described in several clinical cases.66–68 It is also agreed that CBCT is superior to peri-apical radiographs in detecting these fractures, whether they be bucco-lingual or mesiodistal.69–70

In cases with inflammatory root resorption, lesions are detected much easier in early stages with CBCT compared to conventional 2-D X-rays.71–73

Oral and maxillofacial surgery

CBCT can also be used to determine root morphology, the number of roots, canals and accessory canals, as well as to establish the working length and angulations of roots and canals.74–76 In key phrases it is also accurate in assessing root-Canal fillings.77–80 Owing to its accuracy, it is very helpful in detecting the pulpal extensions in talon cusps81 and the position of fractured instruments.82–86

It is also a reliable tool for pre-surgical as assessment of the proximity of the tooth to adjacent vital structures, size and extent of lesions, as well as the anatomy and morphology of roots with very accurate measurements.82–84,86–88,90–93

CBCT images for the same patient. Data obtained from these images regarding bone quality, implant length and diameter, implant location and proximity to vital structures is magnificient.
Additionally, in cases in which teeth are assessed after trauma and in emergency cases, its appli - cation can be a useful aid in reaching a proper diagnosis and treatment approach.18,20,29,30

Recently, owing to its reliability and accuracy, CBCT has also been used to evaluate the canal preparation in different instrumenta - tion techniques.21–23

**Implantology**

With increased demand for replacing missing teeth with dental implants, accurate measure - ments are needed to avoid damage to vital structures. This was achievable with conven - tional CT. However, with CBCT giving more accurate measurements at lower dosages, it is the preferred option in implant den - tistry today (Figs. 4a & b).53,115,131,137–139

With new software that constructs surgical guides, damage is also reduced further.77,103–105 Helland et al.14 describe a tech - nique in which CBCT was used inter-operatively in two cases to navigate the implant insertion following microsurgical bone transfer. CBCT enables the assess - ment of bone quality and bone quantity.148,149,150–152 This leads to reduced implant failure, as case selection can be based on much more reliable information.

**Orthodontics**

Orthodontists can use CBCT images in orthodontic assess - ment and cephalometric analy - sis.153,154–156 Today, CBCT is al - ready the tool of choice in the as - sessment of facial growth, age, airflow function and distur - bances in tooth eruption.157–160 CBCT is a reliable tool in the assessment of the proximity to vi - tal structures that may interfere with orthodontic treatment.161–166 In cases in which mini-screw im - plants are placed to serve as a temporary anchorage, CBCT is useful for ensuring a safe inser - tion161,167 and to assess the bone density before, during and after treatment (Fig. 6).168,169

Having different views in one scan, such as frontal, right and left lateral, 45-degree views and sub-mental, also adds to the ad - vantages of CBCT.161,162 As the im - ages are self-corrected from the magnification to produce or - thogonal images with 1:1 ratio, higher accuracy is ensured. CBCT is thus considered a better option for the clinician.170

**Temporomandibular joint disorder**

One of the major advantages of CBCT is its ability to define the true position of the condyle in the fossa, which often reveals possible dis - location of the disk in the joint, and the extent of transla - tion of the condyle in the fossa.171,172 With its accuracy, measurements of the roof of the glenoid fossa can be done eas - ily.171–174 Another advantage of some of the available devices is their ability to visualise soft tis - sue around the TMJ, which may reduce the need for magnetic resonance imaging in these cases.175

Owing to these advantages, CBCT is the imaging device of choice in cases of trauma, pain, dysfunction, fibro-osseous anky - losis and in detecting condylar cortical erosion and cysts.176,177,178 With the use of the 3-D features, the imageguided puncture technique, which is a treatment modality for TMJ disk adhesion, can safely be performed.179

**Periodontics**

CBCT can be used in assessing a detailed morphologic de - scription of the bone because it has proved to be accurate with only minimal error margins.180,181 The measurements proved to be as accurate as direct measure - ments with a periodontal probe.182,183 Furthermore, it also aids in assessing furcation invol - vements.184,185 CBCT can be used to detect buccal and lingual defects, which was previously not possi - ble with conventional 2-D radi - ographs.186–189 Additionally, owing to the high accuracy of CBCT measurements, intra-bony de - fects can accurately be measured and dehiscence, fenestration de - fects and peri-implant cysts as - sessed.190,191,192,193 CBCT has also proved its superiority in evaluat - ing the outcome of regenerative periodontal therapy.194

**General dentistry**

Based on the available litera - ture, CBCT is not justified for use.
Discussion

CBCT scanners represent a great advance in dento-maxillofacial (DMF) imaging technology, introduced into dental use in the late 1990s, has advanced dentistry significantly. The number of CBCT-related papers published each year has increased exponentially in the last years. The above systematic review of the literature related to CBCT applications in dental practice was undertaken in order to summarise concisely the literature of this new imaging technique in different dental specialties. Cone-beam computed tomography in dentistry—try was used as a dental diagnostic system review. Other terminology encountered in the literature, such as contrast in the volumetric scan, volumetric computed tomography, dental CT, dental 5-D CT and cone-beam volumetric imaging, did not result in additional relevant papers. The clinical applications for CBCT imaging in dentistry are increasing. The results of this review demonstrate that 154 papers were clinically relevant and that the most common clinical applications are in the field of oral and maxillofacial surgery, implant dentistry, and endodontics, CBCT has limited use in operative dentistry owing to the high radiation dose required in routine dental practice.

The literature on CBCT is promising and needs further research, especially with regard to its use in forensic dentistry, in order to explore more potentially beneficial indications in that area. No literature concerning direct CBCT indications in prosthodontics was found. However, several overlapping indications were found in other dental specialties attributing to the final standard of care for implant treatment. These indications include but are not limited to bone grafting, soft-tissue grafting, prosthetically driven implant placement, prosthodontics and temporomandibular joint disorder. CBCT images can also be of great value in special cases in which multiple teeth have to be assessed for restorabilities. 12–24

1. CBCT examinations must not be carried out unless a history and clinical examination have been performed.
2. CBCT examinations must be justified for each patient to demonstrate that the benefits outweigh the risks.
3. CBCT examinations should potentially add new information to aid the patient’s management.
4. CBCT should not be repeated on a patient “routinely” with an out-of-risk/benefit assessment having been performed.
5. When accepting referrals from other dentists for CBCT examinations, the referring dentist must supply sufficient clinical information (results of history and examination) to allow the CBCT practitioner to perform the justification.
6. CBCT should only be used when the question for which imaging is required cannot be answered adequately by lower dose conventional (diagnostic) radiography.

7. CBCT images must undergo a thorough clinical examination (radiological report) by the radiologist (medical radiologist) or, in special cases in which multi-specialist assessment is required, by a specially trained DMF radiologist or, in special cases, by a clinical radiologist (medical radiologist).

At present, the literature on Forensic dentistry is limited. The literature on CBCT is promising and needs further research, especially with regard to its diagnostic value. The European Academy of Den-toMaxilloFacial Radiology has developed the following basic principles on the use of CBCT in dentistry:

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