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CBCT SPECIAL ISSUE: REVIEW ARTICLE

Guidelines for clinical use of CBCT: a review

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Objectives: To identify guidelines on the clinical use of CBCT in dental and maxillofacial radiology, in particular selection criteria, to consider how they were produced, to appraise their quality objectively and to compare their recommendations.
Methods: A literature search using MEDLINE (Ovid®) was undertaken prospectively from 1 January 2000 to identify published material classifiable as "guidelines" pertaining to the use of CBCT in dentistry. This was supplemented by searches on websites, an internet search engine, hand searching of theses and by information from personal contacts. Quality assessment of publications was performed using the AGREE II instrument. Publications were examined for areas of agreement and disagreement.
Results: 26 publications were identified, 11 of which were specifically written to give guidelines on the clinical use of CBCT and contained sections on selection criteria. The remainder were a heterogeneous mixture of publications that included guidelines relating to CBCT. Two had used a formal evidence-based approach for guideline development and two used consensus methods. The quality of publications was frequently low as assessed using AGREE II, with many lacking evidence of adequate methodology. There was broad agreement between publications on clinical use, apart from treatment planning, in implant dentistry.
Conclusions: Reporting of guideline development is often poorly presented. Guideline development panels should aim to perform and report their work using the AGREE II instrument as a template to raise standards and avoid the risk of suspicions of bias.
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Introduction

The arrival of any new medical intervention, diagnostic or therapeutic, brings new challenges to clinicians. Will its introduction be worthwhile in terms of financial cost? Will it give benefits to the patients in terms of quality of life? Will *not* using it put clinicians at a professional disadvantage? The introduction of CBCT for dental and maxillofacial radiology has posed many questions such as these. As described by Fryback and Thornbury,[1] a new radiological technique should be efficacious at all levels, from technical accuracy efficacy to societal efficacy, yet the introduction and growth of CBCT has moved faster than the acquisition of the evidence. CBCT has been available in dental and maxillofacial radiology for well over a decade. Numerous models of equipment are in existence,[2] and there is evidence of widespread use in some countries.[3,4]

Clinical guidelines are a means of providing a framework for the use of a new technology or technique. Guidelines are systematically developed statements designed to assist the clinician and patient in making decisions about appropriate healthcare for certain specific clinical circumstances.[5] There are three fundamental approaches to guideline development. The first is to rely on the opinion of an expert panel's considered judgment. The second is to employ some kind of

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Table 1 Guideline-related search terms used for MEDLINE (Ovid®)

1. guideline*.mp. or exp guideline/
2. position statement.mp.
3. position paper.mp.
4. clinical recommendation*.mp.
5. or/1–4
6. cone beam computed tomography.mp.
7. volumetric radiography.mp.
8. volumetric tomography.mp.
9. digital volumetric tomography.mp.
10. digital volume tomography.mp.
11. Cone-beam.mp. or exp Cone-Beam Computed Tomography/
12. (volume ct or volumetric ct).mp.
13. (volume computed tomography or volumetric computed tomography).mp.
14. CBCT.mp.
15. or/6–14
16. (dental or dentistry).mp.
17. exp dentistry/
18. or/16–17
19. 15 and 18

The search was performed prospectively from 1 January 2000. An initial, focused search was undertaken using these terms, along with a second, broader search excluding lines 6–15, run on the same date.

consensus method and the third is to use "evidence-based" guideline development methodology. Each has advantages and disadvantages, but the aim with any guideline must be to limit the influence of individual opinion and bias. Evidence-based methods are promoted as having the best chance of achieving this by using defined and objective methods based upon systematic review of the literature, with quality assessment of evidence and the grading of recommendations.[6]

In radiology, guidelines can provide assistance in choosing the appropriate imaging pathway and are often called "referral criteria", "selection criteria" or "appropriateness criteria". These are descriptions of clinical conditions derived from patient signs, symptoms or history that identify patients who are likely to benefit from a particular radiographic technique.[7] In medical imaging, the availability of such guidelines is well established.[8,9] There may be a requirement for selection criteria to be available to clinicians. For example, in the European Union, the directive relating to medical uses of ionizing radiation requires that the "Holder" (employer) responsible for an establishment using X-rays on patients provides referral criteria for clinicians.[10] While this may not be the case elsewhere, there remains the ethical need for justification of medical exposures, for which referral criteria provide a framework of good practice.

In the context of CBCT in dentistry, where higher radiation doses are usually seen than in conventional dental radiography,[11,12] it is particularly important to adhere to the radiation protection principle of justification. Guidelines, in the form of selection criteria, can provide the clinician with a helpful framework within which to work. The aim of this review was to identify guidelines on the clinical use of CBCT in dental and maxillofacial radiology, in particular selection criteria, to consider how they were produced, to appraise their quality objectively and to compare and contrast their recommendations.

Methods and materials

The reporting of this review follows, wherever possible, the format recommended in the preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement.[13]

A literature search was undertaken to identify published material classifiable as "guidelines" pertaining to the use of CBCT in dentistry.

Eligibility criteria

To be included, the identified guidelines had to meet three criteria:

- make recommendations on the clinical use (relating to justification and selection criteria) of CBCT in any dentally related speciality
- be aimed at the individual practitioner (any health professional working within dentistry) and/or patient level
- be published in 2000 or after.

No *a priori* language restrictions were set, as it was anticipated that many non-English publications might be amenable to translation by the authors or by colleagues if needed.

Information sources and search strategy

It was anticipated that guideline documents would not necessarily be identifiable by a simple search of the scientific literature, so several strategies were used. The primary method of sourcing guideline publications, a MEDLINE (Ovid®) search, was performed prospectively from 1 January 2000, with a final search date of 18 June 2014. The terms used for the MEDLINE (Ovid) search are shown in Table 1.

In addition, the US National Guideline Clearinghouse (www.guideline.gov) and the Royal College of Surgeons of England (https://www.rcseng.ac.uk/fds/publications-clinical-guidelines/clinical_guidelines) websites were searched on the same date, and an *ad hoc* search of Google using a variety of relevant search terms was undertaken in the expectation of identifying grey literature (*e.g.* governmental agency reports, specialist society documents). Requests for information on guidelines were made on two occasions over the preceding 2 years on the ORADLIST Oral Radiology online discussion group (http://lists.ucla.edu/cgi-bin/mailman/listinfo/oradlist) hosted by the University of California (Los Angeles, CA) requesting information about guidelines or position papers on CBCT. The reference lists of two PhD theses from the University of Manchester, UK, were also hand-searched for relevant guideline publications.

Where guidelines had been updated or published more than once, the most recent version was used for

Table 2 Domains and key items assessed using the AGREE II instrument[14]

Domain	*Key item*
Scope and purpose	The overall objective(s) of the guideline is (are) specifically described
	The health question(s) covered by the guideline is (are) specifically described
	The population (patients, public etc.) to whom the guideline is meant to apply is specifically described
Stakeholder involvement	The guideline development group includes individuals from all relevant professional groups
	The views and preferences of the target population (patients, public etc.) have been sought
	The target users of the guideline are clearly defined
Rigour of development	Systematic methods were used to search for evidence
	The criteria for selecting the evidence are clearly described
	The strengths and limitations of the body of evidence are clearly described
	The health benefits, side effects and risks have been considered in formulating the recommendations
	There is an explicit link between the recommendations and the supporting evidence
	The guideline has been externally reviewed by experts prior to its publication
	A procedure for updating the guideline is provided
Clarity of presentation	The recommendations are specific and unambiguous
	The different options for management of the condition or health issue are clearly presented
	Key recommendations are easily identifiable
Applicability	The guideline describes facilitators and barriers to its application
	The guideline provides advice and/or tools on how the recommendations can be put into practice
	The potential resource implications of applying the recommendations have been considered
	The guideline presents monitoring and/or auditing criteria
Editorial independence	The views of the funding body have not influenced the content of the guideline
	Competing interests of guideline development group members have been recorded and addressed

the assessment, taking into consideration any methods published in previous publications.

Selection of publications

The search results were managed in Endnote X4® (Adept Scientific Ltd, Letchworth, UK). An initial screen of the results was undertaken by a single assessor (A-MG) to remove any documents that were clearly not relevant. A second, more focused screening was undertaken by a second assessor (KH) to determine whether the identified documents truly met the inclusion criteria.

Data collection process

Each identified guideline document that met the inclusion criteria was assessed for quality by two, independent, assessors from a team of five (the four listed authors plus one other). The fifth assessor was used on two occasions where the allocation of publications would have resulted in assessment of a guideline by someone involved in their development. The AGREE Collaboration has defined quality of guidelines as "the confidence that the potential biases of guideline development have been addressed adequately and that the recommendations are both internally and externally valid, and are feasible for practice".[14] The AGREE II instrument assesses the methodological rigour and transparency with which a guideline has been developed, and was used for this review.[14] To make this assessment, the AGREE II instrument requires the appraiser to make a judgment on each of 23 items in 6 domains (Table 2) allocating a quality score between 1 and 7. A score of one was given when there is no information that is relevant to the AGREE II item or if the concept is very poorly reported. A score of seven was given if the quality of reporting was exceptional and where the full criteria and considerations articulated in the AGREE II user's manual were met. Domain scores were calculated by summing up all the scores of the individual items in a domain and by scaling the total as a percentage of the maximum possible score for that domain. AGREE II gives no threshold of adequacy for domain scores but advises that such decisions should be made by the user and guided by the context in which the instrument is being used.

Each included publication was classified into one of three categories according to the method used in developing guideline statements:

- expert based
- consensus based with a clearly defined methodology
- formal evidence based with a clearly defined methodology for assessing evidence and grading of recommendations.

Guidelines in publications described as being achieved by "consensus" were only classified as such where there was demonstrable evidence of a methodology having been used (*e.g.* voting process, Delphi methods).

Guideline statements relating to aspects of justification and selection criteria for CBCT were extracted and classified according to clinical use (*e.g.* implant dentistry, orthodontics, trauma). Agreement and disagreement between guidelines were noted.

Results

Figure 1 shows the flow of articles identified through our searches. Following full text screening and removal

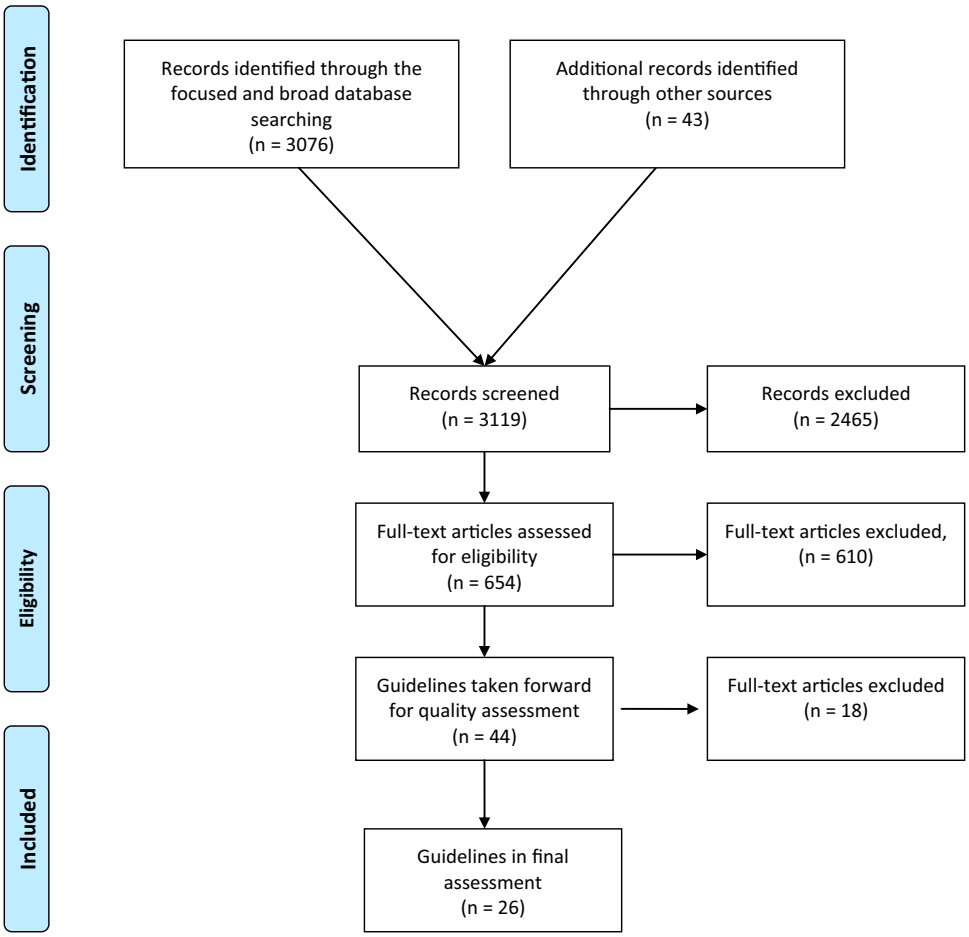

Figure 1 Preferred reporting items for systematic reviews and meta-analyses flow chart[13] depicting the number of records identified, included and excluded at the different stages in the review.

of duplicates, 44 publications remained for quality assessment. However, during the course of quality assessment, some publications were excluded because they were clearly updated or revised versions of other guidelines. In addition, a pragmatic decision was taken to exclude some publications in which the content regarding clinical use (aspects of justification and selection criteria) was extremely limited and which only made explicit referral to other publications included in the review. The final number of publications subjected to quality assessment was 26. Table 3 shows these 26 publications, their date of publication, their mode of development and the clinical areas at which guidelines were aimed.

11 of the included publications (Table 3) were specifically focused on the use of CBCT, whereas the remaining 15 contained recommendations on the use of CBCT. Two of these could have been classified in the former category, as although both related to imaging in implant dentistry, they were both primarily concerned with CBCT.[30,32] Most of the guideline publications were from the USA, UK or European institutions/organizations. Eight publications were judged to be "comprehensive", in that they either gave general guidance on clinical use and aspects of justification or provided multiple guidelines relating to different dental uses.[11,15–20,22,37] Only two documents showed clear reporting of an evidence-based methodology for guideline development.[11,22] The FGDP (UK)[37] used grading of evidence for guideline statements, but there was much inconsistency between sections of the document and it was clear that many guidelines were based on expert opinion only, so this was judged to be an expert-based publication. Two publications could reasonably be classified as consensus guidelines.[16,21] Other publications may have used the term "consensus" in their titles or within the text but gave no evidence of how consensus was achieved; in these cases, it was assumed that "consensus" was being used synonymously with "agreement" rather than indicating the use of a defined methodology. All other publications were classified as expert opinion, although there was great variation in the number and nature of the "experts" involved, ranging from a single author publication[24] to extensive and multidisciplinary panels.[15,37]

The results of the quality assessment using the AGREE II instrument are shown in Table 4. Looking at the six domains considered by the AGREE II tool, some patterns could be seen. There were generally good quality

Table 3 The 26 publications identified in the review, with their year of publication, their method of development and the clinical areas at which guidelines were aimed

Publication	*Year of publication*	*Country or region of origin*	*Method of guideline development*	*Focus of CBCT clinical use*
Guideline publications related specifically to CBCT				
Haute Autorité de Santé[15]	2009	France	Expert opinion	Comprehensive
Horner et al[16]	2009	Europe	Consensus	Comprehensive
American Association of Endodontists; American Academy of Oral and Maxillofacial Radiology[3]	2011	USA	Expert opinion	Endodontics
Hoge Gezondheidsraad[17]	2011	Belgium	Expert opinion	Comprehensive
Noffke et al[18]	2011	South Africa	Expert opinion	Comprehensive
American Dental Association Council on Scientific Affairs[19]	2012	USA	Expert opinion	Comprehensive
Benavides et al[20]	2012	International	Expert opinion	Implant dentistry
European Commission[11]	2012	Europe	Evidence-based methods	Comprehensive
American Academy of Oral and Maxillofacial Radiology[21]	2013	USA	Consensus	Orthodontics
Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften[22]	2013	Germany	Evidence-based methods	Comprehensive
European Society of Endodontology[23]	2014	Europe	Expert opinion	Endodontics
Publications including guideline statements on the use of CBCT				
Handelsman[24]	2006	USA	Expert opinion	Implant dentistry
Isaacson et al[25]	2008	UK	Expert opinion	Orthodontics
Academy of Osseointegration[26]	2010	USA	Expert opinion	Implant dentistry
Drago and Carpentieri[27]	2011	USA	Expert opinion	Implant dentistry
Diangelis et al[28]	2012	International	Expert opinion	Dental trauma
Evans et al[29]	2012	UK	Expert opinion	Endodontics
Harris et al[30]	2012	Europe	Expert opinion	Implant dentistry
Husain et al[31]	2012	UK	Expert opinion	Orthodontics
Tyndall et al[32]	2012	USA	Expert opinion	Implant dentistry
Walter et al[33]	2012	Switzerland	Expert opinion	Periodontology
American Association of Endodontists[34]	2013	USA	Expert opinion	Dental trauma
Cooper and Pin-Harry[35]	2013	USA	Expert opinion	Implant dentistry
Counihan et al[36]	2013	UK	Expert opinion	Orthodontics
Faculty of General Dental Practice (UK)[37]	2013	UK	Expert opinion	Comprehensive
Ngiam et al[38]	2013	Australia	Expert opinion	Sleep apnoea

scores for Domain 1 (scope and purpose) because authors usually communicated the focus of the guideline(s) and the intended context adequately. Scores for Domain 2 (stakeholder involvement) were relatively low, but variable, usually reflecting the absence of any patient or public involvement in guideline development, but also the multidisciplinary nature of the team involved. Domain 3 (rigour of development) also scored variably, with only four publications exceeding 50% for this key aspect.[11,15,22,37] This disappointing result usually reflected incomplete or absent detail of methodology, but all of the key items in this domain were often absent. Clarity of presentation (Domain 4) typically produced a positive (>50%) score. The few exceptions that scored low were usually owing to recommendations being positioned within the text of the document and hard to identify, rather than being highlighted, or were ambiguous in their wording. The ratings for Domain 5 (applicability) were generally very poor, demonstrating an almost uniform failure to consider the implications of guideline implementation. Only one publication was scored positively (58%) in this domain;[37] this was owing to the inclusion of a section on tools for clinical audit in practice.

There was reasonable agreement on the fundamental principle of justification and individual selection of patients for CBCT examinations. On several occasions, it was recommended that CBCT should be reserved as a supplementary imaging technique where conventional radiography failed to answer the question for which imaging was required. The main guideline documents dealing with endodontic uses of CBCT follow this approach.[3,11,23,37] The US-based guideline[3] statement that "CBCT should only be used when the question for which imaging is required cannot be answered adequately by lower dose conventional dental radiography or alternate imaging modalities" concurs almost exactly with the wording of European-based guidelines.[11,15,23,37] This conservative view is reinforced in the recent European Society of Endodontology position statement, which states that "…a CBCT scan should only be considered if the additional information from reconstructed three-dimensional images will potentially aid [in] formulating a diagnosis and/or enhance the management of a tooth with an endodontic problem(s)".[23]

However, there was one example of conflicting guidelines: the use of CBCT in implant dentistry planning,

Table 4 Quality scores of each domain defined by the AGREE II instrument for the included guideline publications, calculated according to the method of Brouwers et al[14]

	AGREE II domains					
Publication	*Scope and purpose*	*Stakeholder involvement*	*Rigour of development*	*Clarity of presentation*	*Applicability*	*Editorial independence*
Guidelines related specifically to CBCT						
Haute Autorité de Santé[15]	86	42	65	78	25	58
Horner et al[16]	72	53	43	78	13	25
American Association of Endodontists; American Academy of Oral and Maxillofacial Radiology[3]	36	19	7	41	0	0
Hoge Gezondheidsraad[17]	92	42	28	72	6	17
Noffke et al[18]	–	–	–	–	–	–
American Dental Association Council on Scientific Affairs[19]	53	50	13	61	2	33
Benavides et al[20]	81	44	23	72	21	17
European Commission[11]	92	78	94	97	38	63
American Academy of Oral and Maxillofacial Radiology[21]	72	36	17	72	4	0
Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften[22]	92	58	75	86	19	58
European Society of Endodontology[23]	64	44	26	58	8	63
Guidelines including statements on use of CBCT						
Handelsman[24]	39	6	0	25	0	0
Isaacson et al[25]	89	53	32	81	2	13
Academy of Osseointegration[26]	42	22	3	28	2	0
Drago and Carpentieri[27]	58	3	0	19	0	0
Diangelis et al[28]	83	47	19	83	0	0
Evans et al[29]	81	36	13	50	0	13
Harris et al[30]	80	64	20	67	6	33
Husain et al[31]	69	33	5	39	0	0
Tyndall et al[32]	91	47	19	69	2	13
Walter et al[33]	64	19	38	53	27	46
American Association of Endodontists[34]	81	25	2	69	0	0
Cooper and Pin-Harry[35]	42	0	0	17	0	0
Counihan et al[36]	50	14	0	6	4	0
Faculty of General Dental Practice (UK)[37]	92	61	61	92	56	38
Ngiam et al[38]	78	28	10	56	6	29

Scores are the mean of two assessors and are expressed as a percentage of the maximum achievable score for that domain.

where three publications have recommended, in the context of CBCT, that cross-sectional imaging should be used in planning all dental implant placements.[18,27,32] Other guidelines maintain that a selective approach is appropriate,[11,15,17,20,22,30,37] while a further group of publications gave equivocal statements.[24,26,35]

Discussion

One challenge in conducting this review was in identifying guidelines. Unlike research studies, which will generally be published in journals, guidelines may be found in a wide variety of locations, such as the websites of specialist societies and colleges, and access may be restricted to members. Thus, we used a variety of search strategies to perform this review, but it is likely that relevant publications were missed. Language was also a limitation, with most non-English documents being identified by personal contacts, the Google search or from the reference lists in the European guidelines.[11] Despite these limitations, the guidelines identified are probably a reasonable reflection of the range of material available to clinicians. It would be of value if developers of clinical guideline documents were required to submit them to national or international repositories, such as the National Guideline Clearing House in the USA. Recently, the Cochrane Collaboration Oral Health

Group has established an International Oral Health Care Guideline Depository (http://ohg.cochrane.org/international-oral-health-guideline-repository) to help identify priority review topics that could inform guideline development, to identify areas of duplication/overlap, where evidence tables could be shared between guideline development groups, and to increase stakeholder involvement in guideline development by widening dissemination. These are admirable aspirations, bearing in mind the limitations of guidelines observed in this review and the duplication of efforts on areas such as the use of CBCT in implant dentistry and endodontics.

Most of the publications were classified as expert opinion based, although some had clearly involved substantial effort of many people to develop. This is disappointing when clinical guideline development methods, such as those described by Scottish Intercollegiate Guidelines Network (SIGN),[39] National Institute for Health and Care Excellence (NICE)[40] and the American College of Radiology[9] are well established. This probably reflects the considerable time commitment involved in undertaking such activities. Looking at the publications listed in Table 3, publications ranged from substantial multinational efforts through to single or double author articles. It could be argued that some or all of the latter should have been excluded. However, these items were self-described as offering "guidelines" to clinicians and were often written in the authoritative and engaging manner of experienced clinicians. Readers of these articles may accept such well-illustrated and easily understood publications as being preferable to other, more "academic" guidelines, so a decision was made to include them in the review.

We restricted the evidence gathering to clinical applications of CBCT, *i.e.* aspects of justification and selection criteria. Consequently, some important publications on CBCT, from national and provincial radiation safety authorities, were not included where they dealt principally with aspects of administrative requirements and radia-tion safety.[41–45] In terms of guidelines on clinical use (selection criteria), the guideline documents identified were heterogeneous. Some were comprehensive and lengthy, including numerous detailed selection criteria for particular clinical situations. Others limited their recommendations to basic principles and did not attempt detailed guideline development. Some publications were guidelines on clinical procedures (Table 3), in which imaging was only a small part, and detailed selection criteria for CBCT were, perhaps understandably, lacking.

There are enormous challenges in developing selection criteria for CBCT in dentistry. The evidence base is still very limited for some clinical uses. While some studies of diagnostic accuracy are achievable where a valid laboratory model can be used (*e.g.* dental fracture diagnosis); for other applications such as periapical inflammatory pathosis, it is impossible to achieve a study design entirely free of risk of bias or applicability problems. There are few studies at the higher levels of hierarchy of diagnostic efficacy in accordance with Fryback and Thornbury[1], to the authors' knowledge at the time of conducting this review, with only one randomized controlled trial having been published on the impact of CBCT on patient outcomes.[46] The many CBCT machines on the market have different image quality and the diagnostic capability of any machine will vary depending upon mode of operation. Thus, it might be argued that we will never be able to develop "definitive" guidelines with high grading of supporting evidence for CBCT. This may well be true, but it does not validate a passive approach from researchers and guideline developers. Instead, efforts should remain focused on producing the best achievable guidelines with a transparent approach to acknowledging where evidence is lacking.

We used the AGREE II appraisal tool[14] to conduct this review in an attempt to assess quality. The AGREE Collaboration defined quality of guidelines as "the confidence that the potential biases of guideline development have been addressed adequately and that the recommendations are both internally and externally valid, and are feasible for practice".[47] The results of our appraisal suggest that many guidelines on clinical use of CBCT fall well short of the ideal. Such a finding is not unique to CBCT or to radiology in general. It is important to recognize that the AGREE II quality scores (Table 3) should not be interpreted as a "league table" or a condemnation of poorly scoring publications. Some guideline documents might be valid in their recommendations; agreement between poorly and highly scoring guidelines for many aspects of clinical use suggest that this is the case. Rather, the quality scores should be seen for what they are: an indicator of the clarity of reporting. Without such clarity, there is a risk that guidelines could inappropriately be accused of bias or errors. The AGREE II instrument should be seen as a template for those developing and presenting guidelines, in a manner analogous to the use of the Standards for Reporting of Diagnostic Accuracy statement for the reporting of diagnostic accuracy studies (http://www.stard-statement.org/). Furthermore, there was not perfect agreement between assessors of each publication using the AGREE II tool. While there was no evidence of contrary judgments on specific items, the scores allocated might not agree. In retrospect, the use of three, or ideally four, assessors might have been desirable.

Patient and public involvement is widely seen as an essential part of guideline development and implementation[48,49] and is often straightforward when guidelines are being developed for particular clinical conditions, such as cancer or chronic diseases, because well-established and highly motivated patient organizations and pressure groups usually exist. By contrast, it is particularly challenging to identify a means of patient and public involvement when developing guidelines on diagnostic tests, as highlighted in the guideline document from Germany.[22] Nonetheless, patient and public involvement is

not impossible to achieve, and strategies have been developed.[50] It is reasonable to expect that development of any clinical guideline would involve representation from all professional groups that it may affect. Some publications in this review demonstrated a multidisciplinary authorship, notably the European Commission[11] document, but others were restricted to one professional group, such as the radiologists. This inevitably weakens any guideline and can increase the risk of accusations of bias. The AGREE II instrument specifically highlights the need for involvement of at least one methodology expert within the development group (*e.g.* systematic review expert, epidemiologist, statistician, library scientist etc.).[14]

It is important to recognize that some publications may have performed a comprehensive and systematic literature review and have linked their recommendations to the strength of the evidence yet simply failed to report this. Statements were seen in the preamble to some reviewed publications such as "a systematic literature review was performed". The absence of detail about the search strategy and method of critical appraisal was insufficient and might add to suspicion of bias. Few publications recorded that external review had been performed. Of course, in cases published in journals, it would be expected that peer review would have been performed prior to acceptance, but review by independent assessors prior to journal submission is a desirable feature in guideline development and is essential where a guideline is published outside the normal journal framework, *e.g.* on a website.

The practicalities of implementation of clinical guidelines, both facilitators and barriers, should be considered when presenting them to the target user groups. Failure to do this may partially explain why guidelines may be ignored. The final domain (editorial independence) was scored very poorly for most publications, owing to the typical absence of acknowledgment of the interests of the funding body and records of potential or real conflicts of interest within the authors/guideline development group. These are straightforward items to include in publications, and there should be no difficulty in scoring high here.

The conflict observed between guidelines on the use of CBCT in implant dentistry planning was notable. It is not the purpose of this review to argue either case, and the subject has recently been considered in a systematic review by Bornstein et al.[51] Nonetheless, it is important to remember that the publications reviewed by us were presumably based on the same evidence, yet came to different conclusions. Disagreement between guidelines may be an influential factor in health professionals ignoring them. This emphasizes the need for a transparent and robust methodology in guideline development.

Whether to use CBCT or not in the "real" world is influenced by numerous factors.[52] There is evidence that there is high variation in prescription of dental radiographs nationally and internationally, which is not explained by levels of dental health or wealth in society. Dentists are inevitably influenced by teachers, both as undergraduates and during continuing education. Financial pressures may favour the use of certain clinical techniques, such as CBCT, if they can increase profits; it has been demonstrated in the UK that removal of payments for radiography and other clinical activities leads to a reduction in their use.[53] It is therefore of interest that, in the context of pre-surgical use of CBCT as an aid in third molar surgery, recent evidence suggests that using CBCT substantially increased costs compared with using panoramic radiography but without any change in the resources used for surgery, post-surgical treatment or patient complication management.[54] An influential factor is that some dentists' training on the appropriate use of CBCT may be limited to that received from manufacturers and suppliers who may be selective in their communication of research evidence for their product. Clinical use of CBCT is as open to such influences as any other dental procedure. Thus, it is important to "fight the good fight" and promote practice based on the evidence. Furthermore, it is in the interests of those of us who are involved in guideline development to follow best practice, as indicated by AGREE, to limit the risks of bias and potential criticism.

Conclusions

Reporting of guidelines on clinical use of CBCT is often poorly presented. Prospectively, guideline development panels should aim to perform and report their work using the AGREE II instrument as a means of raising standards and avoiding the risk of suspicions of bias. In particular, bearing in mind the limitations and deficiencies in publications reviewed here, guideline developers should be sure to assemble a multidisciplinary team of stakeholders to formulate guidelines. They should perform systematic review and critical appraisal of the evidence, recognize the limitations of the available evidence and clearly link their recommendations to it. Guidelines should be externally reviewed prior to publication, and clear implementation strategies and tools for monitoring and clinical audit should be available.

Conflict of interest

KH was involved in the development of four publications included in the review, while A-MG was involved in the development of one publication.

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