Development of an evidence-based clinical imaging diagnostic guideline for implant planning: Joint recommendations of the Korean Academy of Oral and Maxillofacial Radiology and National Evidence-based Healthcare Collaborating Agency

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ABSTRACT

Purpose: This study was conducted to develop an evidence-based clinical imaging diagnostic guideline for implant planning, taking into account efficacy, benefits, and risks.
Materials and Methods: The guideline development process employed the adaptation methodology used for Korean clinical imaging guidelines (K-CIG). Core databases (Ovid-Medline, Ovid-Embase, National Guideline Clearinghouse, Guideline International Network) and domestic databases (KoreaMed, KMbase, and KoMGI) were searched for guidelines. The retrieved articles were analyzed by 2 reviewers, and articles were selected using well-established inclusion criteria.
Results: The search identified 294 articles, of which 3 were selected as relevant guidelines. Based on those 3 guidelines, 3 recommendations for implant planning were derived.
Conclusion: We recommend radiography or cone-beam computed tomography (CBCT) scanning for individual patients judged to require a cross-sectional image after reading of a panoramic X-ray image and a conventional intraoral radiological image. Various steps should be taken to raise awareness of these recommendations among clinicians and the public, and K-CIG should be regularly reviewed and revised. *(Imaging Sci Dent 2020; 50: 45-52)*

KEY WORDS: Implant; Imaging; Radiography; Cone-Beam Computed Tomography

Introduction

Diagnostic imaging is an essential component of treatment planning in oral rehabilitation through implant placement.[1] Clinicians can use conventional radiography or cone-beam computed tomography (CBCT) for diagnostic imaging. CBCT enables clinicians to obtain 3-dimensional images.[2] However, since the radiation doses of dental CBCT are usually higher than those of conventional (2-dimensional) radiography, it is very important to consider the risks of radiation exposure when using CBCT for diagnostic purposes in dentistry.[3]

Clinical guidelines are systematically developed statements that assist clinicians and patients in making decisions about the most appropriate care for specific clinical circumstances. In other words, guidelines can be helpful in situations that require clinicians to choose an appropriate imaging modality. Guidelines are often referred to as "selection criteria" or "referral criteria."

In the field of radiology, developed countries utilize evidence-based clinical imaging guidelines (CIG) to augment

the clinical decision-making of physicians when requesting or prescribing a radiological examination. In Korea, the methodology of developing guidelines is to adapt CIG by modifying previously developed guidelines to make them suitable for the local healthcare environment.[4] Through this process, this study aimed to develop an evidence-based Korean clinical imaging guidelines (K-CIG) for implant planning, taking into account efficacy, benefits, and risks.

Materials and Methods

Development of Korean CIG for implant planning

The guideline development process involved a collaboration between the Korean Academy of Oral and Maxillofacial Radiology (KAOMFR) and the Korean Society of Radiology, and the National Evidence-based Healthcare Collaborating Agency (NECA) organized a development committee and working group to develop this guideline.

Three experts in oral and maxillofacial radiology experts comprised the working group. The working group, research methodology specialists, and clinical guideline specialists who supported the overall planning and research methodology comprised the development committee.[4] They published a description of the methodology of the guideline adaptation process that was applied in this study. A consensus group consisted of 5 nominated members from the final 5 related academic societies who participated in the symposium conducted to establish a consensus.

Defining the key question

Questions were generated in the form of population/patient, intervention/index test, comparator/control, and outcome (PICO) questions by the working group and were reviewed by the development committee and the consensus group. The following key question was identified: for a patient scheduled for implantation, what is the appropriate imaging modality?

Guideline search

Core databases such as Ovid-Medline, Ovid-Embase, National Guideline Clearinghouse, and Guideline International Network were searched for guidelines. Additionally, 3 domestic research databases (KoreaMed, KMbase, and KoMGI) were searched from 2000 to the first week of March 2017. The pre-search yielded 51 article abstracts. The extensive searches of databases used the terms "dental implant," "radiograph," "guideline," "recommendation," and "practice guideline." The working group reviewed the search strategy and results and performed additional searches to ensure the inclusion of any important omitted guidelines.

Selection of the searched guidelines

According to pre-defined selection criteria, 2 members of the working group independently reviewed the literature during the primary screening process and secondary selection process to ensure objectivity. The primary screening process involved reviewing the title and abstract of the identified studies and guidelines. In the secondary selection process, the full text of the identified studies was reviewed, and the reasons for excluding studies were noted.

The inclusion criteria for guidelines were as follows: 1) the study population included patients scheduled for implantation, 2) the study intervention was CBCT, 3) the study comparators were panoramic and periapical radiographs, 4) the study assessed the effectiveness of CBCT for evaluating alveolar bone morphology in edentulous regions and its surrounding structures, 5) the study presented a practice guideline, 6) the study presented recommendations, 7) the study utilized an evidence-based method, and 8) the study was published in Korean or English.

The exclusion criteria were as follows: 1) patients of interest for the key question were not included, 2) a key question-related imaging examination was not included, 3) appropriate results (diagnostic accuracy, efficacy, safety, prognosis, and patients' preferences) were not reported, 4) the study presented non-clinical practical guidelines, 5) recommendations were not suggested, 6) the guidelines were not produced via an evidence-based method, 7) the guidelines were reported in neither English nor Korean, 8) the study was an overlapping publication, and 9) the full text was not obtainable.

Disagreements between reviewers were resolved either by consultation between the reviewers or by obtaining input from a third reviewer.

Search for recent literature

Randomized controlled trials (RCTs) and observational studies were searched, and the recent literature (since 2011) was reviewed.

Quality assessment

The finally selected guidelines underwent quality appraisal using the Korean Appraisal of Guidelines for Research and Evaluation II (AGREE II) tool.[5] Two appraisers from the development committee independently assessed

Table 1. Search results from domestic literature databases

Searching date: March 8, 2017

Search site	Search term	Searched studies	Note
KoreaMed	"Dental Implant" [ALL] AND radiograph* Limits = Practice Guideline	0	Year limitation: since 2000
	Sum	0	
KMbase	([ALL = implant installation] AND [ALL = radiographic examination] AND [ALL = guideline])	0	Year limitation: since 2000
	([ALL = implant installation] AND [ALL = bleeding] AND [ALL = recommend])	0	
	([ALL = implant installation] AND [ALL = bleeding] AND [ALL = guideline])	0	
	(([ALL = Dental Implant] AND [ALL = radiograph]) AND [ALL = recommendation])	0	
	(([ALL = Dental Implant] AND [ALL = radiograph]) AND [ALL = guideline])	0	
	Sum	0	
	After omitting overlapping studies	0	

the selected literature. Each evaluation category was scored on a scale ranging from 1 to 7 points, and the reasoning behind the scores was noted to ensure clarity and reproducibility of the assessment results. If there was a difference >4 in scores for any of the categories among the appraisers, the study was re-examined. In essence, guidelines that scored 50 or above in the "rigor of development" domain were considered candidates for inclusion in the development process of Korean CIG (K-CIG).[4]

Grading the level of evidence and drafting the recommendation document

This step assessed whether an identified guideline was up-to-date, acceptable, and applicable. The level of evidence of the K-CIG was merged with the evidence level of individual studies, and was categorized as high (I), moderate (II), low (III), or very low (IV).

A draft of the recommendation document consisted of recommendations for the key question, summary, and evidence; considerations for the recommendation and references; and each recommendation with its overall evidence level. The recommendations in the K-CIG were graded as A, B, C, or I, indicating the strength of the recommendation.

External review and approval of the clinical guideline

The finalized recommendation document was reviewed both internally by clinical imaging experts who did not participate in the development of the guideline and externally by related society members (end-users of the guideline). Appropriate modifications were made after collecting opinions.

Results

PICO

The guideline was developed based on the key question, which was generated from the PICO questions by the working group. In this study, the population comprised patients scheduled for implantation. The intervention was CBCT. The comparators were panoramic and periapical radiographs. The outcome was the effectiveness of CBCT for evaluating alveolar bone morphology in edentulous patients and its surrounding structures.

Search for guidelines

The search results from domestic databases are shown in Table 1. No results were obtained from KoMGI. The search results from international databases are shown in Tables 2 and 3. By searching for "dental implant," 5 search results were obtained from the Guideline International Network and National Guideline Clearinghouse databases.

Selection of searched guidelines

A total of 294 guidelines were retrieved from the databases. After the exclusion of duplicates, 51 guidelines remained. Finally, 3 guidelines were selected in accordance with the inclusion and exclusion criteria (Fig. 1).

Search for recent studies

The recent literature (since 2011) was reviewed. This starting point was 3 years earlier than the most recent guideline. RCTs and observational studies that were identified by applying condition number 4 in Table 4 were read; as a result, 6 studies were selected.

Table 2. Search results from international databases: Ovid-Medline (1946 to first week of June 2017)

Searching date: Jun 8, 2017

	Search term	Search result
P (population)	dental implant$.mp. or Immediate Dental Implant Loading/ or Dental Prosthesis, Implant-Supported/	34,406
	Dental Implantation, Endosseous/ or Dental Implants/ or Dental Implant*.mp. or Dental Implantation/	31,021
	1 or 2	34,406
I (intervention)	Cone-Beam Computed Tomography.mp. or Cone-Beam Computed Tomography/	7,418
	Radiography, Dental, Digital/ or Radiography/ or Radiography, Dental/ or Radiography, Panoramic/ or Radiography.mp.	403,580
	periapical radiograph.mp.	136
	4 or 5 or 6	409,676
P & I guideline	3 AND 7	63,024
	guideline$.ti.	56,686
	practice guideline.pt.	23,238
	recommendation$.ti.	28,043
	guideline.pt.	16,544
	9 or 10 or 11 or 12	106,370
P & I & guideline	P AND I AND 13	16
P & guideline	P AND 13	135
Limitation	P & I & guideline 2006~current	12
	P & guideline 2006~current	86

Table 3. Search results from international databases: Ovid-Embase (1974 to week 23 of 2017)

Searching date: Jun 8, 2017

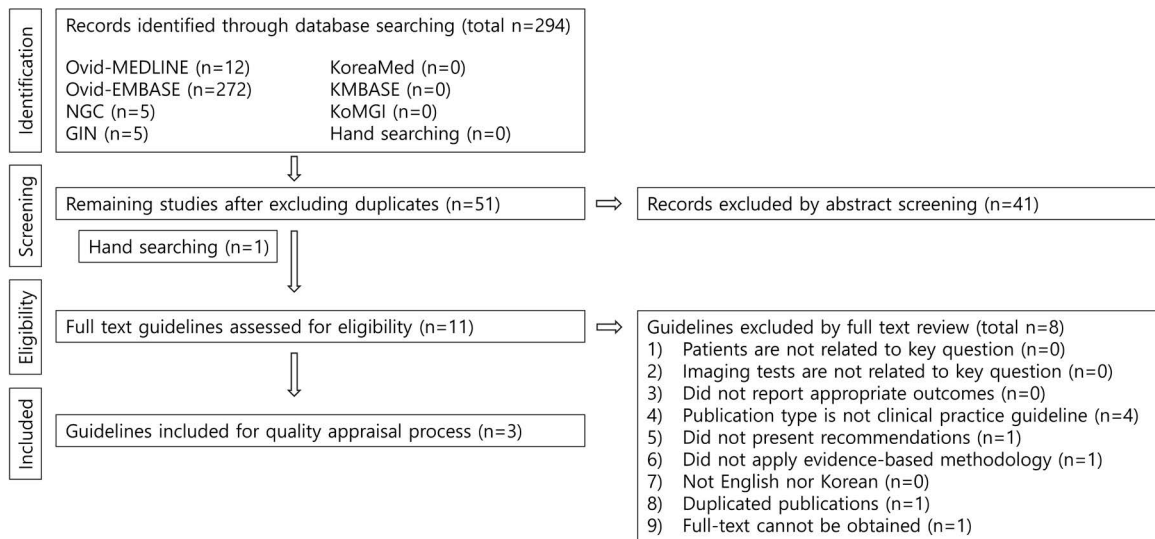|	Search title	Search result
P (population)	edentulousness/ or tooth prosthesis/ or denture/ or dentistry/ or tooth implant/ or tooth implantation/ or dental implant*.mp. or dental surgery/	155,281
I (intervention)	Cone-Beam Computed Tomography.mp. or computer assisted tomography/ or cone-beam computed tomography/ or single photon emission computer tomography/	683,365
	tooth radiography/ or Radiography.mp. or radiography/	548,309
	periapical radiograph.mp.	155
	2 or 3 or 4	1,099,180
P & I guideline	1 AND 5	10,569
	guideline$.ti.	56,686
	recommendation$.ti.	28,043
	7 or 8	118,152
P & I & guideline	P AND I AND 9	33
P & guideline	P AND 9	657
Limitation	P & I & guideline 2006~current	21
	P & guideline 2006~current	272

Fig. 1. The guidelines identified by searching were selected by step-by-step screening. This is the flow diagram of guideline selection.

Table 4. Search results of recent literature through Ovid-Medline In-Process and Other Non-Indexed Citations and Ovid-Medline from 1946 to present

Searching date: Oct 12, 2017

	Search term	Search result
P (population)	dental implant$.tw. or Immediate Dental Implant Loading/ or Dental Prosthesis, Implant-Supported/	17,818
	Dental Implantation, Endosseous/ or Dental Implants/ or Dental Implantation/	28,672
	1 or 2	33,862
I (intervention)	Cone-Beam Computed Tomography.tw. or Cone-Beam Computed Tomography/	9,540
	Radiography, Dental, Digital/ or Radiography/ or Radiography, Dental/ or Radiography, Panoramic/ or Radiography.tw.	375,388
	periapical radiograph$.tw.	1,542
	4 or 5 or 6	384,195
P & I	3 AND 7	3,742
Year limitation	limit 8 to yr = "2011-Current"	1,727
RCTfilter	exp Randomized Controlled Trials/ or Random*.mp. or RCT.mp. or exp Controlled Clinical Trial/ or exp Placebo Effect/ or exp Placebos/ or Placebo.mp. or trial.mp.	1,759,548
Observational study filter	exp Epidemiologic Studies/ or exp Case-Control Studies/ or exp Cohort Studies/ or exp Seroepidemiologic Studies/ or Case control.mp. or cohort stud*.mp. or cohort analys*.mp. or Follow up stud*.mp. or observational stud*.mp. or Longitudinal.mp. or Retrospective.mp.	2,563,395
	9 and 10-RCT	310
	9 and 11-Observational study	733
	After omitting overlapping studies (#12)	296
	After omitting overlapping studies (#13)	697

RCT: randomized controlled trial

Quality assessment

Table 5 presents the results of the quality assessment of the 3 guidelines using the AGREE II instrument.[5] All 3 guidelines received scores > 50 in the "rigor of development" domain, and the committee recommended consulting them. The titles of the 3 guidelines are presented below.

Table 5. Results of the quality assessment of the guidelines using the Korean version of the Appraisal of Guidelines for Research and Evaluation II (AGREE II) instrument (%)

Domain	AGREE II instrument domains					
	Domain 1. Scope and purpose	Domain 2. Stakeholder involvement	Domain 3. Rigor of development	Domain 4. Clarity of presentation	Domain 5. Applicability	Domain 6. Editorial independence
Guideline 1	94	72	54	89	0	67
Guideline 2	67	78	56	89	29	92
Guideline 3	94	78	90	89	33	67

Table 6. Recommendation matrix of the existing guidelines

Source guidelines	Recommendation	Grade of recommendation
Guideline 1: CBCT in implant dentistry: a systematic review focusing on guidelines, indications, and radiation dose risks	Practitioners who prescribe or use CBCT units should design specific CBCT equipment protocols that are task specific and incorporate the imaging goal for patient's specific presenting circumstances. The protocol should include considerations of exposure (mA and kVp), minimum image-quality parameters (e.g., number of basis images, resolution), and restriction of the FOV to visualize adequately the region of interest.	Not available
Guideline 2: Consensus statements and recommended clinical procedures regarding contemporary surgical and radiographic techniques in implant dentistry	The clinician performing or interpreting CBCT scans for implant dentistry should take into consideration current radiologic guidelines. The decision to perform CBCT imaging for treatment planning in implant dentistry should be based on individual patient needs following thorough clinical examination. • When cross-sectional imaging is indicated, CBCT is preferable over CT. CBCT imaging is indicated when information supplemental to the clinical examination and conventional radiographic imaging is considered necessary. CBCT may be an appropriate primary imaging modality in specific circumstances (e.g., when multiple treatment needs are anticipated or when jawbone or sinus pathology is suspected). • The use of a radiographic template in CBCT imaging is advisable to maximize surgical and prosthetic information. • The FOV of the CBCT examination should be restricted to the ROI whenever possible. • Patient- and equipment-specific dose reduction measures should be used at all times. • To improve image data transfer, clinicians should request radiographic devices and third-party dental implant software applications that offer fully compliant DICOM data export.	Not available
Guideline 3: Radiation No. 172 CBCT for dental and maxillofacial radiology (evidence-based guidelines)	CBCT is indicated for cross-sectional imaging prior to implant placement as an alternative to existing cross-sectional techniques where the radiation dose of CBCT is shown to be lower. **D** For cross-sectional imaging prior to implant placement, the advantage of CBCT with adjustable fields of view, compared with MSCT, becomes greater where the region of interest is a localized part of the jaws, as a similar-sized field of view can be used **GP**	D,GP

CBCT: cone-beam computed tomography, FOV: field of view, ROI: region of interest, DICOM: Digital Imaging and Communications in Medicine, MSCT: multislice computed tomograph

Guideline 1: CBCT in implant dentistry: a systematic review focusing on guidelines, indications, and radiation dose risks[6]

Guideline 2: Consensus statements and recommended clinical procedures regarding contemporary surgical and radiographic techniques in implant dentistry[7]

Table 7. Results of the assessment of acceptability and applicability

	Acceptability and applicability	Guideline 1. Bornstein et al.[6]	Guideline 2. Bornstein et al.[7]	Guideline 3. European commission[8]
Acceptability	Similarity of population	Yes	Yes	Yes
	Similarity of value and preference	Yes	Yes	Yes
	Similarity of benefit by recommendation	Yes	Yes	Yes
	Generally, acceptable	Yes	Yes	Yes
Applicability	Applicability of intervention/instrument	Yes	Yes	Yes
	Applicability of essential technique	Yes	Yes	Yes
	No legal and institutional barriers	Yes	Yes	Yes
	Generally, applicable	Yes	Yes	Yes

Guideline 3: Radiation No. 172 CBCT for dental and maxillofacial radiology (evidence-based guidelines)[8]

Conventional imaging was recommended in all 3 guidelines as an appropriate examination modality for patients scheduled for implant placement. If insufficient information is obtained via conventional imaging, CBCT can be a next step. The domestic acceptability and applicability of the 3 guidelines were acceptable (Table 7).

Grading the level of evidence and drafting the recommendation document

Based on the 3 guidelines (Table 6), 3 recommendations were proposed, for which the recommendation grade and evidence level are as follows:

Recommendation 1. In the absence of a clinical abnormality in the oral cavity, a panoramic X-ray examination and periapical radiological examination of the relevant part of the alveolar bone are necessary to determine the status of the bone and the shape of adjacent anatomical structures (recommendation grade A, evidence level II).

Recommendation 2. A CBCT scan should be performed for each patient judged to require a cross-sectional image after reading of the panoramic X-ray image and intraoral radiological image (recommendation grade B, evidence level II).

Recommendation 3. A CBCT scan can be used as the primary test for patients clinically suspected to have pathological abnormalities of the jaw or the maxillary sinus (recommendation grade B, evidence level II).

Finalizing the recommendation document

Reviews can be performed using different methods, such as conducting a seminar to hear directly from the users and holding a public meeting with the head of the Consumer Protection Committee, newspaper reporters, and healthcare officials. To make this guideline useful for clinicians who request imaging examinations, the recommendations will be disseminated widely through diverse methods, such as academic presentations and public communication. The developed Korean clinical imaging diagnostic guideline (K-CIG) will be re-assessed annually, and may be revised if new key evidence is presented.

Discussion

This study aimed to develop a guideline for the appropriate use of various radiographical modalities for Korean patients scheduled for implantation. In the future, we will use this method to create a Korean guideline for more than 50 PICO questions that clinicians would like to be clarified. Joint recommendations were made by the KAOMFR and NECA, following the adaptation process of evidence-based CIGs. One of the 3 selected guidelines was identified through a manual search, because the guideline developed by the SEDENTEXCT research project is only provided on their website. Therefore, the compiled guideline has been posted for easy access worldwide. Furthermore, we will create a mobile application for this guideline, which will make it easy for end-users to see the guideline on their mobile phones.

All 3 guidelines for the method of examination of patients scheduled for implantation, which received scores >50 scores in the "rigor of development" domain, uniformly recommended conventional imaging, such as panoramic radiography. It was recommended to use a panoramic radiograph to decide whether a CBCT scan is necessary.

We recommended CBCT scanning in individual patients judged to require a cross-sectional image after reading of a panoramic X-ray image and a conventional intra-oral

radiological image.[6,9] More specifically, a cross-sectional image after panoramic radiography is needed in the following conditions in the maxilla:[8] (a) an incisive canal, (b) descent of the maxillary sinus, (c) doubt regarding the sinus septum in sinus grafting, (d) doubt about the shape of the alveolar ridge, and (e) pathosis. In the mandible, the conditions requiring a cross-sectional image are: (a) doubt about the position of the mandibular canal or mental foramen, (b) doubt about the shape of the alveolar ridge, (c) severe resorption, and (d) pathosis.

A benefit of CBCT is that it provides a cross-sectional view of the residual alveolar bone with a lower radiation dose than multislice computed tomography (MSCT). Additionally, when acquiring images using a radiological marker, an appropriate plan can be made considering the implant direction. However, CBCT is inadequate for evaluating bone quality. Unlike MSCT, the grayscale values in CBCT images are not reliable; thus, evaluating density objectively is challenging. However, the grayscale values of CBCT images have been reported to be correlated with implant retention.[10] Evaluating the residual alveolar bone using CBCT has the advantages of less radiation exposure than conventional MSCT and an adjustable field of view so that clinicians can observe only the necessary part.[8]

The radiation dose for each examination was 7.2 μSv for panoramic radiography,[11] 1-8.3 μSv for periapical radiography,[12] and 11-674 μSv for CBCT of the alveolar bone.[8] Since CBCT has a large effective dose difference depending on the region of interest, it is recommended to adjust the exposed site based on the ROI.[13]

The working group gathered guidelines and determined their domestic acceptability and applicability through consensus.

We have prepared a plan for effective dissemination of this guideline by consensus of the committee to strengthen its application. To improve the applicability of the generated guideline, we will publish articles in leading journals and create and use a clinical decision support system as a domestic mobile application.

In conclusion, this study was the first to develop an evidence-based CIG for implant planning in Korea. As subsequent activities, applicability and monitoring are recommended to ensure that the application of the guideline in clinical settings is fully justified. Additionally, K-CIG should be regularly reviewed and revised.

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