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Digital subtraction radiography in TMJ imaging: A critique

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To the Editor:

I am writing in response to a recent article published in the June issue of *Imaging Science in Dentistry* by Demirturk Kocasarac and Celenk titled "Effectiveness of digital subtraction radiography in detecting artificially created osteophytes and erosions in the temporomandibular joint."[1]

The authors compared the diagnostic efficacy of panoramic radiography and panoramic digital subtraction radiography (DSR) in the detection of simulated osteophytes and erosions in the mandibular condyles. The authors concluded, "In the current study, the diagnostic accuracy of DSR was found to be higher than the accuracy of panoramic imaging for the detection of erosions." I note the following flaws in the study that make such a conclusion questionable.

1. A serious problem with this study is that the radiographs were taken without any effort to implement a standardization technique to stabilize the projection geometry. Studies have shown that the level of standardization of the projection geometry greatly influences the performance of the subtraction radiography.[2] In other words, reproducible projection geometry as well as identical contrast and density of the serial radiographs are essential prerequisites for successful DSR. However, the authors do not seem to appreciate the importance of achieving reproducible projection geometry.
2. The authors claimed that panoramic radiography requires less radiation than cone-beam computed tomography (CBCT). In fact, this concept has been overused to the point of losing its originality. The authors should note that new CBCT technologies yield lower radiation dose levels than traditional 2-dimensional (2D) imaging methods when scans are obtained with low-dose protocols.[3] Thus, practitioners can reap the benefits of 3-dimensional (3D) imaging at a substantially lower radiation dose.
3. The authors anticipated that DSR might provide an alternative approach to 3D imaging modalities (e.g., computed tomography [CT]/CBCT, magnetic resonance imaging) in diagnosing temporomandibular joint disorders (TMD). First, the authors should be aware that TMD is an umbrella term including all conditions related to the temporomandibular joint and associated musculoskeletal structures. Second, their opinion is absolutely unfounded.

In summary, this study does not demonstrate the potential for panoramic DSR to be used in the clinical setting.

I hope the authors will consider my comments in their future work.

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Response by the authors

1. The authors compared the diagnostic efficacy of panoramic radiography and panoramic digital subtraction radiography (DSR) in the detection of simulated osteophytes and erosions in the mandibular condyles. The authors concluded, "In the current study, the diagnostic accuracy of DSR was found to be higher than the accuracy of panoramic imaging for the detection of erosions." I note the following flaws in the study that make such a conclusion questionable.

A serious problem with this study is that the radiographs were taken without any effort to implement a standardization technique to stabilize the projection geometry. Studies have shown that the level of standardization of the projection geometry greatly influences the performance of the subtraction radiography.[2] In other words, reproducible projection geometry as well as identical contrast and density of the serial radiographs are essential prerequisites for successful DSR. However, the authors do not seem to appreciate the importance of achieving reproducible projection geometry.

Answer. Mandibular condyles were stabilized in a fixed position relative to the glenoid fossa and articular eminence with a removable silicone-based impression material. The skulls were fixed on an adjustable tripod apparatus for positioning in the panoramic machine.[1]

The tripod was placed in exactly the same place for all experiments. Since skulls were used in the experiment, it is impossible to have a motion artefact. As can be seen from the experimental design, reproducible projection geometry was achieved.

We do know that identical contrast and density of the serial radiographs are essential prerequisites for successful DSR. That is why we took all measures to ensure consistent acquisition geometry and settings, including identical contrast and brightness.

The Emago dental image archiving software allows the operator to choose a few reference points on the radiographs to achieve an optimal match of 2 panoramic images for the DSR image. Thus, corresponding anatomical landmarks were identified in each pair of images. We used anatomical landmarks because doing so was considered representative of the application of projective standardization in a clinical setting.

In order to standardize the image quality, we used the same settings (kV, mA) for all techniques and observers were not allowed to modify the contrast or brightness of images so that the same image parameters were maintained. To zoom in, if needed, we were able to use the magnification option of the Windows 7 Home Basic program.

With all due respect, we think that assuming that we do not appreciate the importance of achieving reproducible projection geometry is a demeaning remark. The study showed that DSR performed better than panoramic images in detecting arthritic-like changes, even though, according to the remarks (which are completely wrong), we did not ensure perfect standardization. So what would the results have been if we did?

2. The authors claimed that panoramic radiography requires less radiation than cone-beam computed tomography (CBCT). In fact, this concept has been overused to the point of losing its originality. The authors should note that new CBCT technologies yield lower radiation dose levels than traditional 2-dimensional (2D) imaging methods when scans are obtained with low-dose protocols.[3] Thus, practitioners can reap the benefits of 3-dimensional (3D) imaging at a substantially lower radiation dose.

Answer. New CBCT technologies may yield lower radiation dose levels than traditional 2D imaging methods when scans are obtained at low-dose protocols, but this is not the case for all—and especially the most commonly used—CBCT machines. Note also that low-dose scan protocols can reduce the image resolution and generate some noise that compromises the ability of the scans to detect mild changes related to initial degenerative changes.

Marques et al.[2] showed that the sensitivity of CBCT for detecting bone defects depends on the size of the defects. This information was also confirmed by Patel et al.[3] in a study of simulated condylar lesions. Very small defects (i.e., <2 mm) were shown to be difficult to detect despite the overall high sensitivity (72.9%-87.5%). In the same study, the authors also investigated the effect of different voxel sizes (0.4 and 0.2 mm) and concluded that the sensitivity increased significantly for small defects with an increase in scanning resolution. It is known that an increase of the scanning resolution may lead to an increase in the radiation dose. They stated that, for simulated defects with both diameter and depth smaller than 2 mm, approximately 1 in 3 defects were undetected when using CBCT images with the 0.4 mm voxel size.

In our study, we stated that panoramic radiography re-

quires less radiation exposure than CT/CBCT. When we consider that CBCT machines are still somewhat expensive to buy for many practitioners across the world, many practitioners still may not reap the benefits of CBCT and may send their patients for a CT scan, which is more common and gives a higher radiation dose than many CBCT machines and panoramic radiographs.

3. The authors anticipated that DSR might provide an alternative approach to 3D imaging modalities (e.g., computed tomography [CT]/CBCT, magnetic resonance imaging) in diagnosing temporomandibular joint disorders (TMD). First, the authors should be aware that TMD is an umbrella term including all conditions related to the temporomandibular joint and associated musculoskeletal structures. Second, their opinion is absolutely unfounded.

Answer. We stated that our findings showed that DSR might also have the potential for clinical application for diagnosing TMD, and yes, we are aware that TMD is an umbrella term including all conditions related to the temporomandibular joint and associated musculoskeletal structures. In this study, our findings showed that DSR was useful for detecting osseous changes (osteophyte and erosion), but this does not mean that DSR does not have the potential to detect other osseous changes; therefore, we did not want to limit the possible application areas. "MIGHT" represents a possibility and not a certainty.

I fail to understand how the author of this response can conclude with such an assertive statement: "Second, their opinion is absolutely unfounded." We think this is not ethical or appropriate, and that making such a statement without any proof shows the author's bad intentions. This statement is just the author's own idea, and it should not have been stated so casually without any scientific proof. This study is based on—but is not exactly the same as—a previously published study[1] in an eminent radiology journal; we did not come up with previously untried experimental conditions. Therefore, the findings are scientific, and we can make comments and have opinions based on our results. The author of the response should not disregard this so easily and say our opinions are unfounded.

In summary, this study does not demonstrate the potential for panoramic DSR to be used in the clinical setting.

Answer. In the article, we stated that "further experimental and clinical studies should be done to confirm this potential. To our knowledge, there has been no study investigating the potential of clinical application of DSR for TMD. As for future perspectives, ongoing studies comparing DSR and CT/CBCT may also show that DSR may open up an alternative diagnostic approach to TMJ disorders".

We already mentioned in our article that further studies are needed to investigate the application of DSR in the clinical setting. The author of the response should be aware that almost all scientific data are first obtained in the in vitro setting and then applied to the in vivo setting. It has been like this for ages. However, it is obvious that the author did not seem to devote enough time and attention to understanding the current study.

I hope the authors will consider my comments in their future work.

Answer. We would, if the remarks were less demeaning and degrading. The response author did not point out any valuable information corresponding to steps that we did not perform in our study and could consider for future studies. We hope the author of the response will consider our comments in his or her future critiques and will be more constructive if he or she feels the need to give his or her opinion about other studies.

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