

Three-dimensional assessment of mandibular advancement 1 year after surgery

Felipe de Assis Ribeiro Carvalho, Lucia Helena Soares Cevidanes, Alexandre Trindade Simões da Motta, Marco Antonio de Oliveira Almeida, and Ceib Phillips
Rio de Janeiro, Brazil, and Chapel Hill, NC

Introduction: This prospective observational study evaluated changes in the 3-dimensional position and remodeling of the mandibular rami, condyles, and chin at splint removal and 1 year after mandibular advancement surgery.

Methods: Presurgery, splint removal (4-6 weeks postsurgery), and 1-year postsurgery cone-beam computed tomography scans of 27 subjects were used. Superimposition on the cranial base was used to assess positional or remodeling changes in the anatomic regions of interest. Surface distance displacements were visually displayed and quantified by 3-dimensional color maps. A 1-sample *t* test was used to assess the average postsurgical changes of each region of interest. The level of significance was set at 0.05.

Results: After antero-inferior chin displacement with surgery (mean, 6.81 ± 3.2 mm at splint removal), the average 1-year postsurgery displacement was not statistically significant ($P = 0.44$). Postsurgical adaptations greater than 2 mm were observed in 48% of the patients: 16% with an additional anterior-inferior displacement of the chin of 2 to 4 mm, and 4% with ≥ 4 mm; 20% had postero-superior movement of 2 to 4 mm, and 8% had postero-superior movement of ≥ 4 mm. The condyles tended to move, on average, ≤ 2 mm supero-posteriorly with surgery, and this small positional displacement was maintained 1 year postsurgery (right condyle, $P = 0.58$; left, $P = 0.88$). The rami exhibited outward (lateral) movements with surgery, with greater displacement of the inferior part of the rami (≥ 2 mm in 65% of the subjects). This torque of the ramus with surgery was stable 1 year postsurgery.

Conclusions: Three-dimensional assessment of skeletal changes with mandibular advancement surgery shows that nearly half of the patients have >2 mm change in chin position from splint removal to the 1-year follow-up, with approximately equal chances of anterior and posterior movement. Torque of the rami usually occurs with mandibular advancement surgery.

Read the full text online at: www.ajodo.org, pages S53.e1-S53.e12.

EDITOR'S COMMENT

Cone-beam computed tomography (CBCT) has become a popular diagnostic tool in implant dentistry. Its 3-dimensional (3D) capabilities permit the surgeon to more accurately plan for implant replacement, especially in patients with questionable bony support. In the past, radiographic machines, such as the NewTom, iCAT, PreXion, Kodak, and others were too expensive for private practitioners. But today, these machines are affordable and are purchased by oral and maxillofacial surgeons to provide the information necessary to successfully and predictably place implants. With the growth of this radiographic technique, clinicians in private practice are now looking for other uses of this technology. Could CBCT be a valuable adjunct in the management of patients undergoing orthognathic surgery? If so, what types of information can be obtained from a 3D image that previously unavailable from conventional 2-dimensional (2D) radiographic techniques?

These authors compared the 3D changes in the position of the mandible in subjects who had undergone mandibular advancement surgery. CBCT scans were made before jaw surgery, immediately after surgery, and 1 year postoperatively. The authors superimposed the resulting skeletal maps to determine what happened to the chin, rami, and condyles. Although their methodology documented some interesting findings, they stated that their results corroborate results from previous studies with traditional 2D radiographic techniques—ie, submentovertex radiographs. Yes, there were differences in the chin position between the 3D and 2D radiographic interpretations, but does the increase in radiation exposure justify this limited increase in information? A study published in 2003 from the Department of Diagnostic Sciences from the same institution showed that a CBCT scan results in a 3- to 7-times increase in radiation exposure compared with a panoramic radiograph. So, with that in mind, I am posing 4 questions to the authors.

Vincent G. Kokich

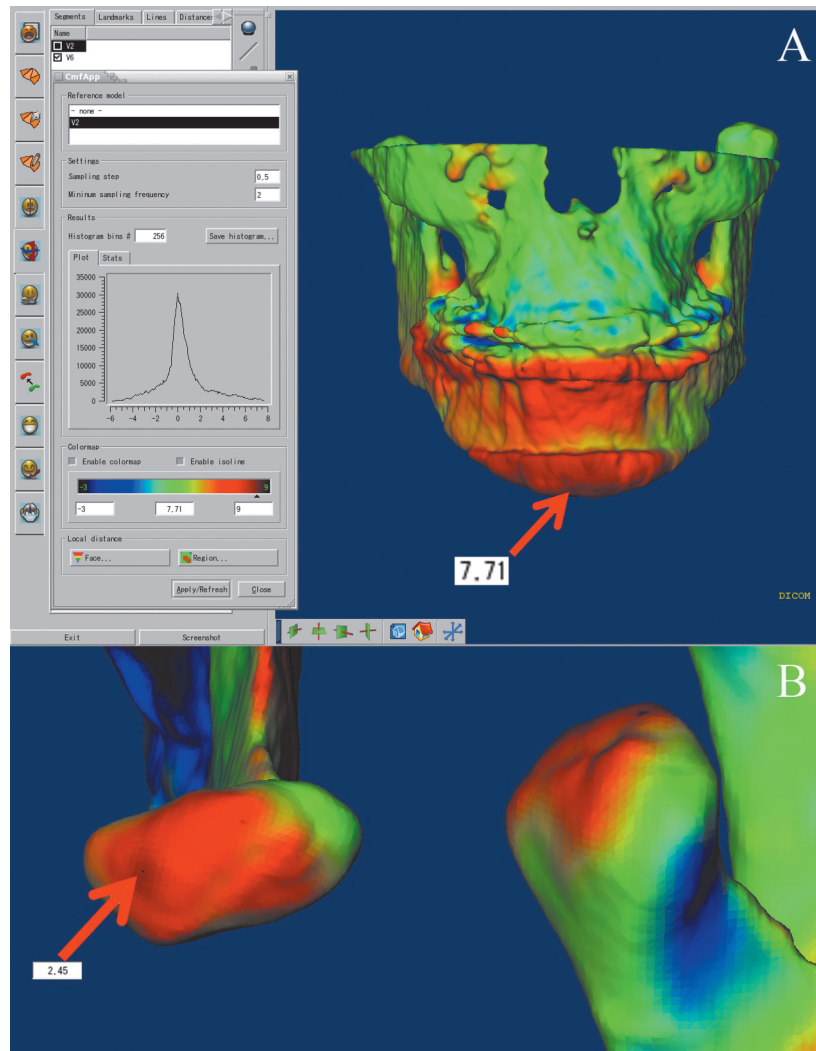


Fig 3. The isoline tool of the CMF application allows the identification of the greatest displacement of a specific anatomic region. The isolines connect areas or points with similar characteristics and can be adjusted to measure specific areas of the color maps. **A**, Example of 7.71-mm chin advancement (presurgery to splint removal, immediate surgical outcome); **B**, condyle displacement after surgery measured with the isoline tool showing a 2.45-mm posterior-superior displacement of a right condyle.

Q & A

Kokich: What was the increase in radiation dosage to each patient with CBCT compared with lateral cephalometric radiography?

Cevidane: The adult doses from the large field-of-view Newtom 3G examinations are 68 μ Sv, according to the International Commission on Radiological Protection (ICRP).^{1,2} This is equivalent to about 8 days of naturally occurring background radiation.² In this study, 1 CBCT scan was taken instead of the

3 routine x-rays (panoramic, lateral, and antero-posterior cephalometric) for each surgical patient at presurgery, splint removal, and 1 year postsurgery. The increase in radiation dose depends on the imaging technique used.¹⁻⁵ Ludlow and Ivanovic⁵ described effective doses (per the ICRP) in microsieverts as follows: full-mouth radiographs (FMX) with photo-stimulable phosphor (PSP) storage or F-speed film with rectangular collimation, 34.9 μ Sv; 4-image posterior bitewings with PSP or F-speed film with rectangular collimation, 5.0 μ Sv; FMX

with PSP or F-speed film with round collimation, 170.7 μSv ; FMX with D-speed film and round collimation, 388 μSv ; panoramic Orthophos XG (Sirona Group, Bensheim, Germany) with charge-coupled device (CCD), 14.2 μSv ; panoramic ProMax (Planmeca, Helsinki, Finland) with CCD, 24.3 μSv ; posteroanterior cephalogram with PSP, 5.1 μSv ; and lateral cephalogram with PSP, 5.6 μSv .

Kokich: Now that the experiment has yielded its results, can you justify the increased radiation dosage—ie, does the risk justify the rewards?

Cevidanes: As careful clinicians, we should not expose patients to unnecessary radiation. The diagnostic benefits of CBCT in this study outweighed the risks. Our studies were designed in consultation with our radiology department experts. Carefully planned studies can highlight important clinical questions that cannot be addressed with current 2D imaging methods. Bone adaptive changes postsurgery include remodeling and mandibular rotations in response to altered muscular patterns. Surgical displacements and adaptive remodeling responses occur relative to adjacent structures in the craniofacial complex. The mandibular rotations postsurgery could be influenced by maxillary, mandibular, and articular fossae morphologies; positioning and interrelationships; and type of surgical movement. There is still uncertainty regarding the envelope of correction possible with 1-jaw and 2-jaw procedures and the influence of surgical displacements on bone remodeling and resorption. These issues cannot be addressed with 2D imaging methods. We expect that studies like this will improve our understanding of the accurate location and nature of the various adaptations after surgical procedures.

Kokich: Do you believe that clinicians in private practice should begin taking CBCT radiographs of their orthognathic surgery patients to create a database for future studies?

Cevidanes: I do not believe clinicians should begin taking CBCT scans for all surgery patients. A clear

guideline is needed to aid them in deciding which imaging technique is most helpful in specific orthodontic situations. Imaging technique selection should be based on well-defined diagnostic criteria that have not yet been determined. Definitions of these criteria will be a critical step so that these diagnostic tools can really improve treatment for patients with significant problems.

Kokich: What is the added cost in the public sector or a private practice for 3 CBCT scans compared with 3 lateral cephalometric radiographs?

Cevidanes: None at this point. Although initial diagnostic CBCT images can be a valuable tool for specific patients in private practice, longitudinal CBCT acquisitions must be carefully planned. Criteria and tools to guide clinicians on the use of CBCT are still being developed and validated. We want to clarify that this study aimed to address important clinical questions with regard to the stability of surgery by using methods previously validated for this purpose. This study showed considerable individual variability in the stability of the corrections 1 year postsurgery. Nearly half of the patients had >2 mm postsurgical changes. These findings show more marked variability in the postsurgery stability than did any previous 2D study.

REFERENCES

1. Valentin J. The 2007 recommendations of the International Commission on Radiological Protection. Publication 103. Ann ICRP 2007;37:1-332.
2. Ludlow JB, Davies-Ludlow LE, White SC. Patient risk related to common dental radiographic examinations: the impact of 2007 International Commission on Radiological Protection recommendations regarding dose calculation. J Am Dent Assoc 2008;139:1237-43.
3. Ludlow JB. Regarding "influence of CBCT exposure conditions on radiation dose." Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:627-8; author reply 628-9.
4. Palomo JM, Rao PS, Hans MS. Influence of CBCT exposure conditions on radiation dose. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;105:773-82.
5. Ludlow JB, Ivanovic M. Comparative dosimetry of dental CBCT devices and 64 row CT for oral and maxillofacial radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;106:930-8.