Temporomandibular Joint Imaging Using CBCT: Technology Now Captures Reality!

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Introduction

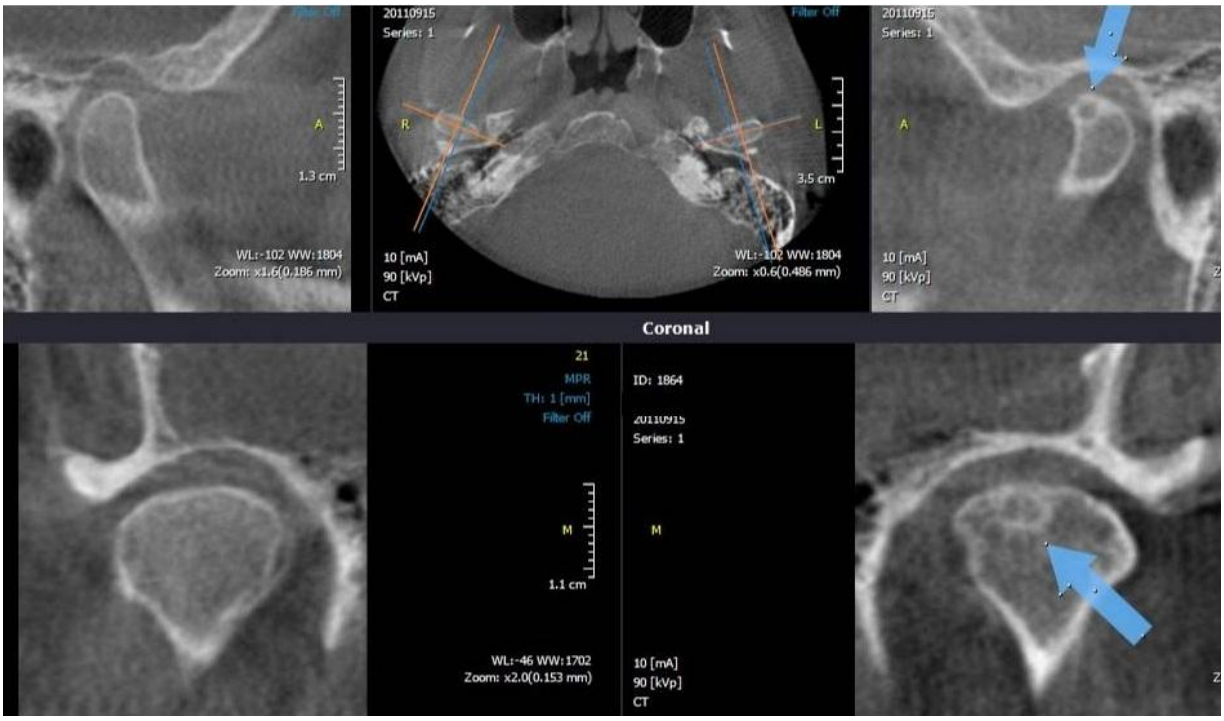
Over many years dentists and dental specialists have moved from transcranial plain film images through tomography and conventional CT as well as specialized panoramic imaging of the temporomandibular joint complex to arrive at Cone Beam CT CBCT). This latest imaging modality is making life easy for those clinicians who must evaluate the heart tissues of the temporomandibular joint complex in patients with orofacial pain. Now, for the first time, we can actually visualize both pathology and anatomy in high resolution thin slice grayscale views, 3-D color reconstructed views and even more detailed views using virtual endoscopy and robust third-party software. No longer are confined to "scout" film panoramics, linear or complex tomography or even high dose, less resolute conventional CT for visualizing the condylar head. Radiographic interpretation of the temporomandibular joint complex including the condyle using CBCT imaging allows clinicians to find more subtle osteoarthritic changes such as subchondral cysts, subchondral sclerosis, osteophyte formation, surface erosion and bony remodeling consistently and with more certainty to make their clinical decision-making simpler. Let's now examine some of these osteoarthritic changes for which CBCT imaging makes their characterization easy.

Subchondral Cyst Formation

Subchondral cyst formation is an early indicator of osteoarthritic changes in the joint surface. I cannot honestly say that I have a good example, even after 35 years of looking at panoramic and other TMJ images using tomography or other plain film techniques, of a subchondral cyst. However, having looked at over 12,000 CBCT scans, I can easily identify such cysts and embed images of them into reports that I produce for my clients. Figure 1 demonstrates examples of subchondral cyst formation.

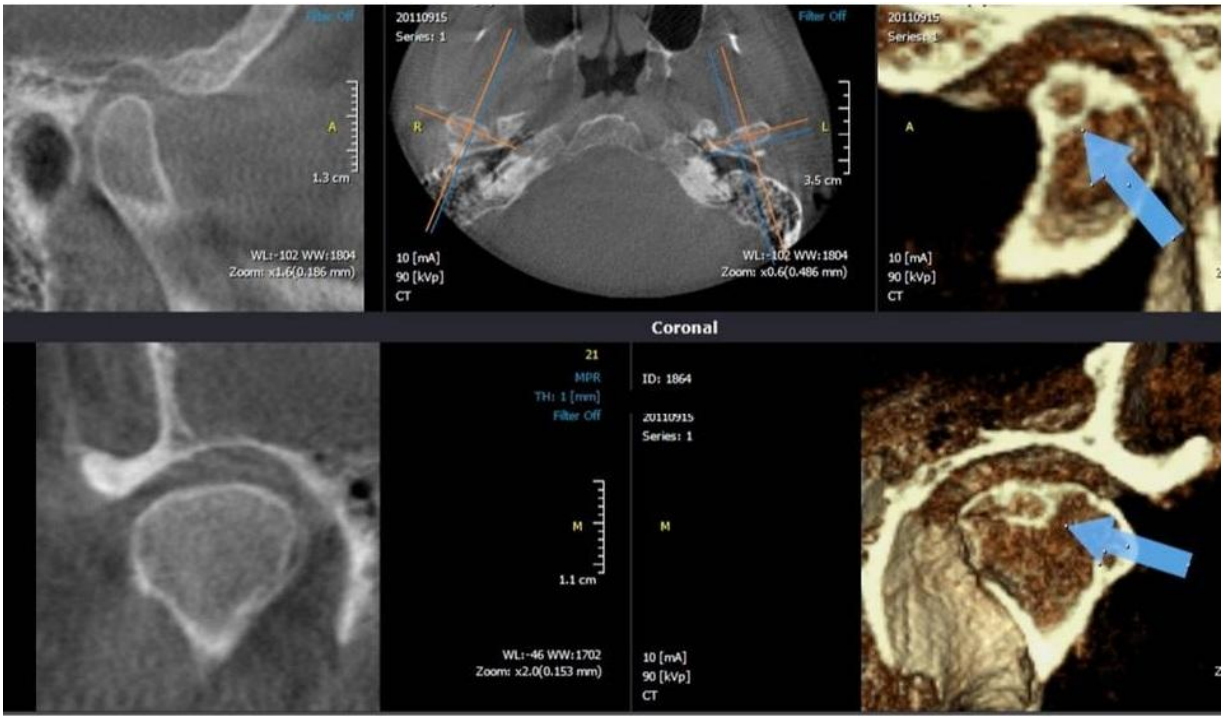
a b

Figure 1a. *Small circular radiolucency seen on the left condyle in the sagittal plane just inferior to the cortical margin.* ***Figure 1b.*** *The same lesion seen in the coronal plane of section. In this view it is more ovoid and appears to have a septation.*



c

Figure 1c. *the same lesion seen reformatted in the OnDemand3D software for a bilateral TMJ comparison. The right condylar head appears normal, the left reveals the same lesion seen in figures 1a and 1b above.*



d

Figure 1d. *Subchondral cyst formation visualization in thin slice (10mm) 3-D reconstructed view.*

Subchondral Sclerosis

Subchondral sclerosis is an increased intensity or thickening of the cortex below a cartilaginous surface. It can occur on the condylar head or on the opposing surface of the glenoid fossa. It is often seen in conjunction with subchondral cyst formation. Loss of joint space, subchondral sclerosis and subchondral cyst formation are considered the radiographic hallmarks of osteoarthritis. In long-standing rheumatoid arthritis there is also a tendency for the joint surface, especially in the TMJ complex, to exhibit sclerotic change. This cortical alteration has been identified in the past even on conventional panoramic images, either on film-based images or with newer digital, solid-state detectors.

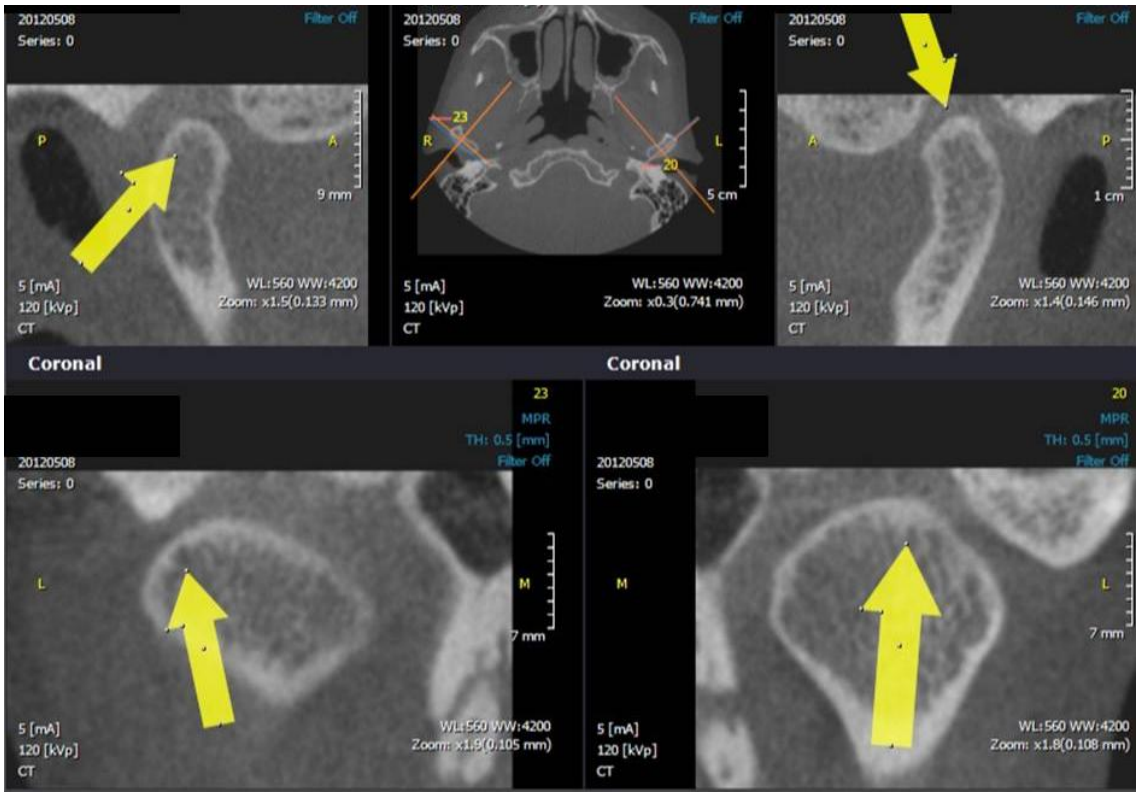


Figure 2a. *Thin slice sagittal and coronal reconstructed views showing subchondral sclerosis on the left condylar head and subchondral cyst formation on the right.*

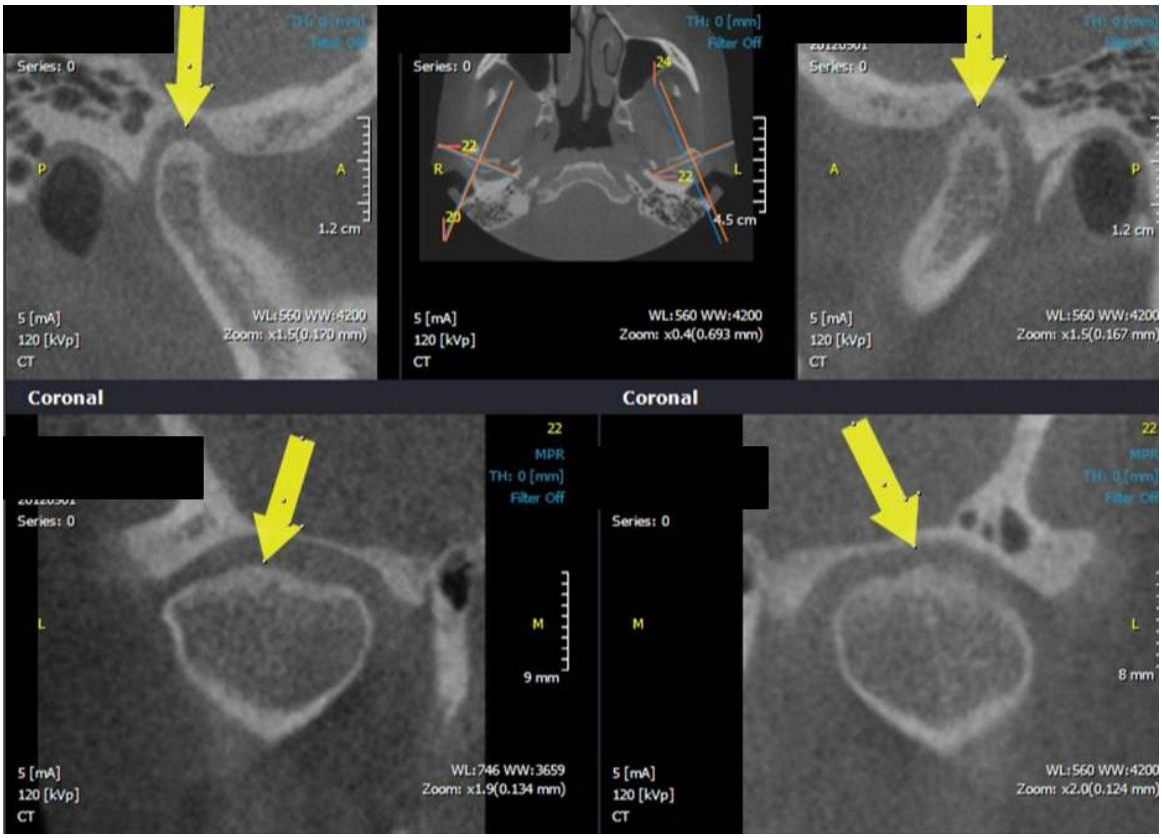


Figure 2b. *Subchondral sclerosis is seen on both condylar heads in these thin slice sagittal and coronal reconstructions.*

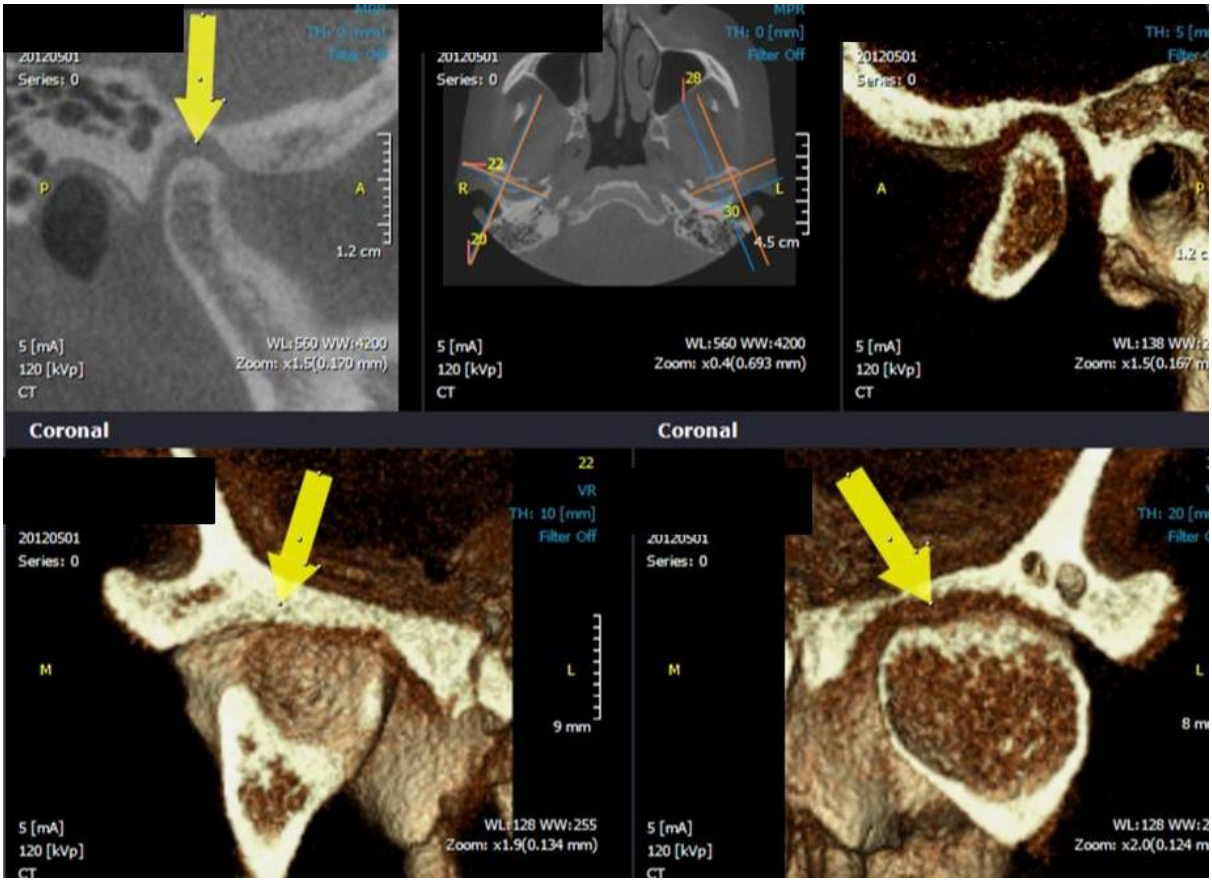


Figure 2c. *3-D color reconstructions in 10 mm sections reveal the subchondral sclerosis on these condylar heads. In addition on the right condyle there is some mild lipping towards the lateral pole. Lipping is also a sign of osteoarthritic change.*

Lipping

The formation of a liplike structure, as at the articular end of a bone in osteoarthritis (Source: http://www.biology-online.org/dictionary/Lipping). With older imaging modalities we often spoke of a "bird beak" appearance which was indicative of an osteophyte and/or osteoarthritic change. With 3-D color CBCT imaging we now see that there are very few "bird beaks". Tomography, transcranial and panoramic views used in the past underestimated of the changes and gave a false appearance depending on the slice thickness or from not viewing the condyle from a truly lateral perspective. Figures 3a to figure 3c demonstrate the past problem in the future solution.

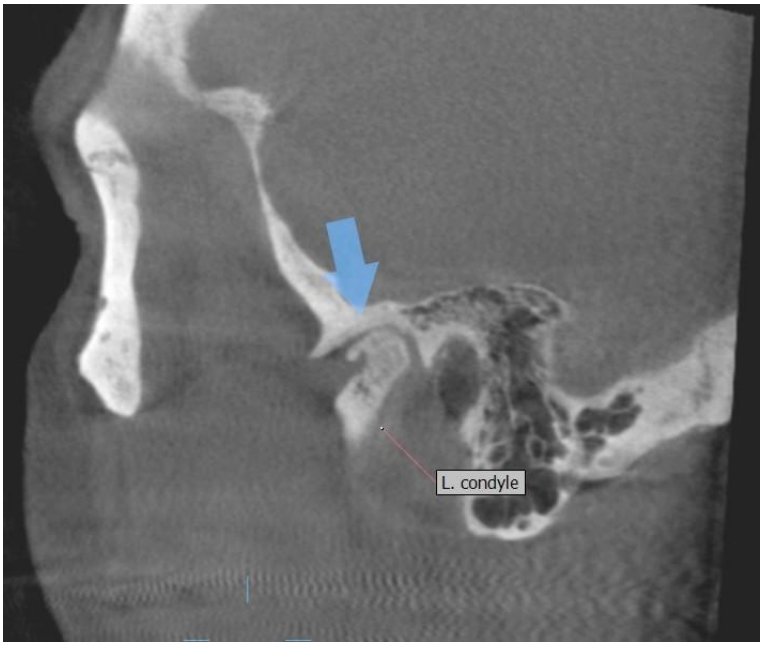


Figure 3a. *A thin slice (0.1mm) sagittal view through the patient's left condyle showing a projection on the anterior surface of the condylar head. In the past this would've been called a "bird beak". This appearance along with the loss of joint space would seduce the clinician into calling this osteoarthritis.*

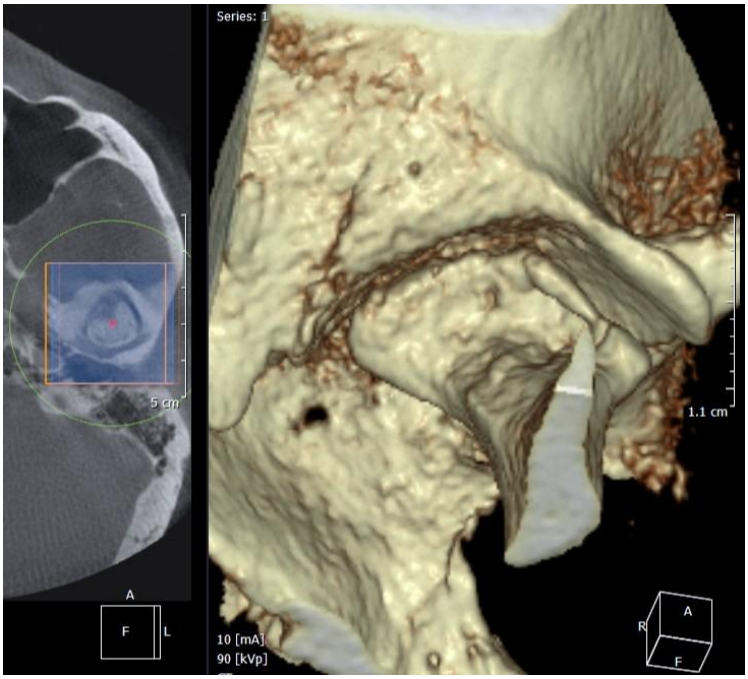


Figure 3b. *Using a "cube tool" in a third-party software called OnDemand3D (CyberMed, Irvine, CA), a 3-D color reconstruction confirms that there is a deep pterygoid fovea and significant "lipping" on the anterior aspect of the condyle. There is no bird beak.*

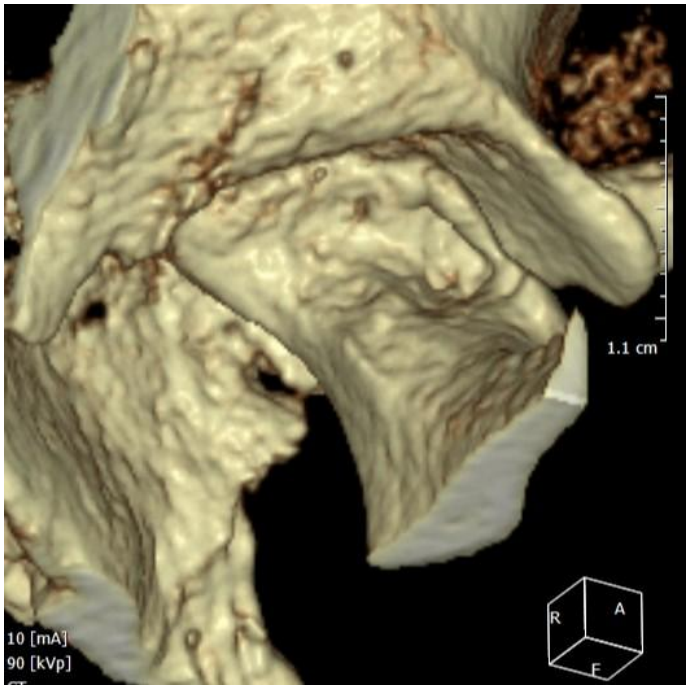


Figure 3c. *a close-up of the 3-D color reconstruction, slightly rotated, to help the clinician visualize the true morphology of the condylar head.*

Surface Erosions

Surface erosions are also common features in osteoarthritis. Until now these changes have been more difficult to demonstrate on the TMJ condyles. However CBCT imaging, especially 3-D color reconstructions, allows the clinician to visualize these smaller surface changes like never before.

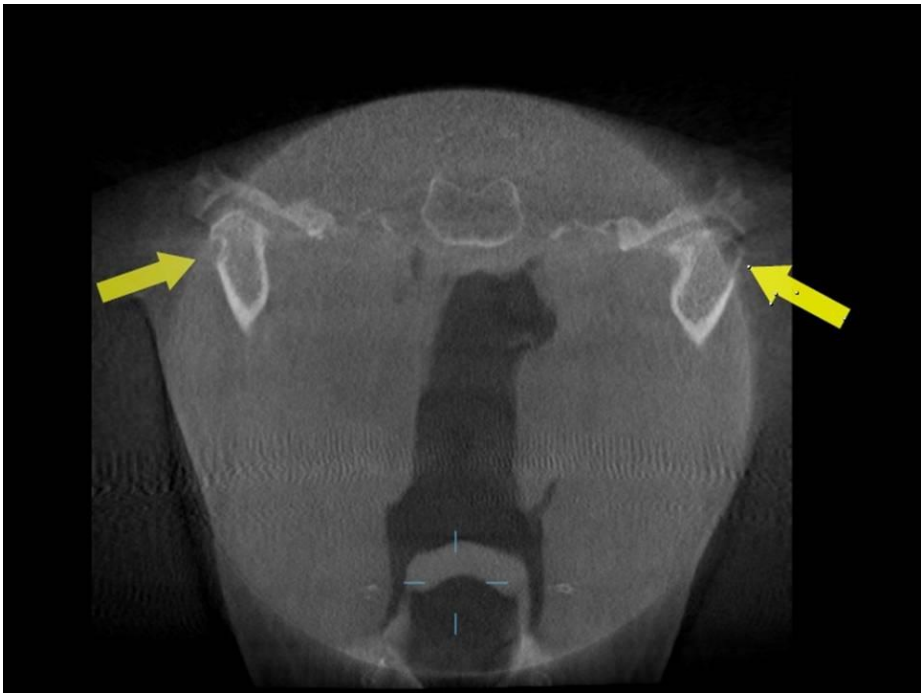


Figure 4a. *Radiolucencies on each condyle near the lateral pole suggestive of erosions.*

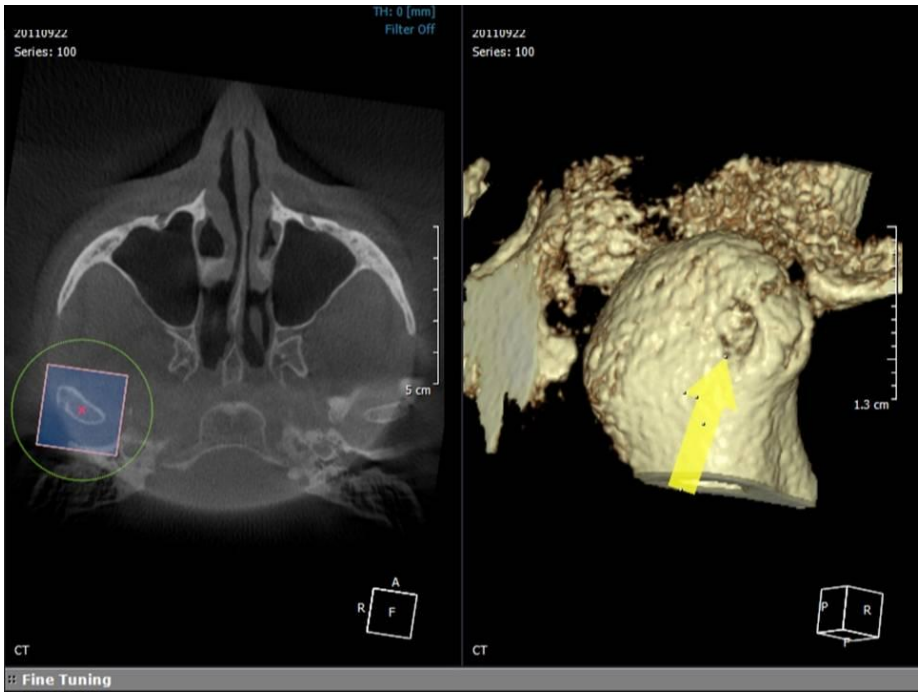


Figure 4b. *3-D color reconstruction using the "cube tool" confirms presence of a surface erosion on the condyle just posterior to the lateral pole.*

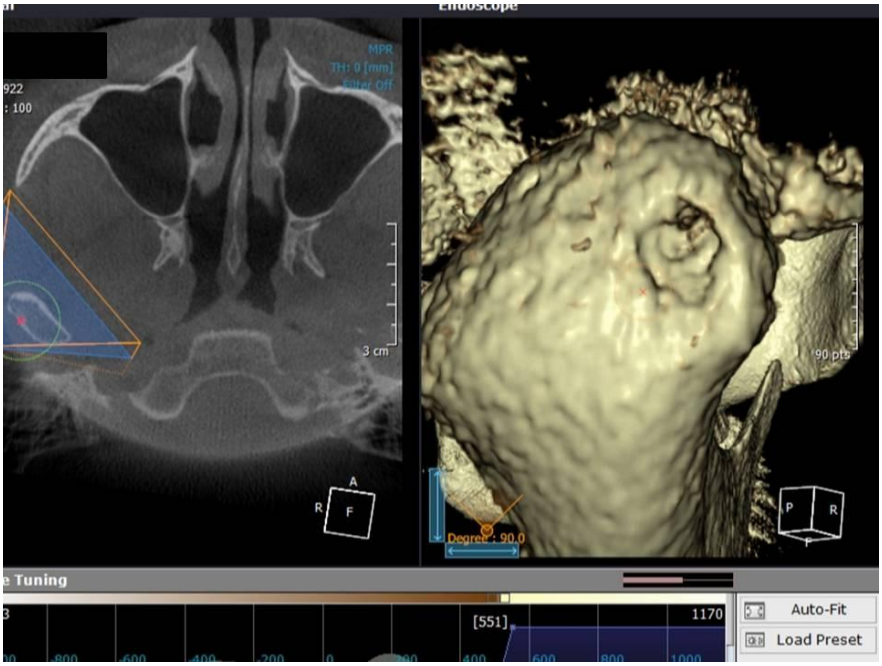


Figure 4c. *This 3-D color reconstruction also employed a "virtual endoscopy tool" which allowed an even more detailed visualization of this erosion and subcortical defect.*

Condylar comparison

When a patient presents with orofacial pain which the clinician suspects to be related to the temporomandibular joint condyles it is imperative to compare both sides. This is slightly more cumbersome with smaller FOV machines since two views of the condyles are necessary and must be acquired separately. If evaluation of patients with orofacial pain is a large part of the dental practice, a larger FOV CBCT machine may be indicated. A single image acquisition allowing comparison of both sides while evaluating a single volume is probably a more preferable arrangement for this patient population.

It is much easier to compare the condyles in a single multiplanar views or in specialized CBCT temporomandibular joint views as seen in the images below.

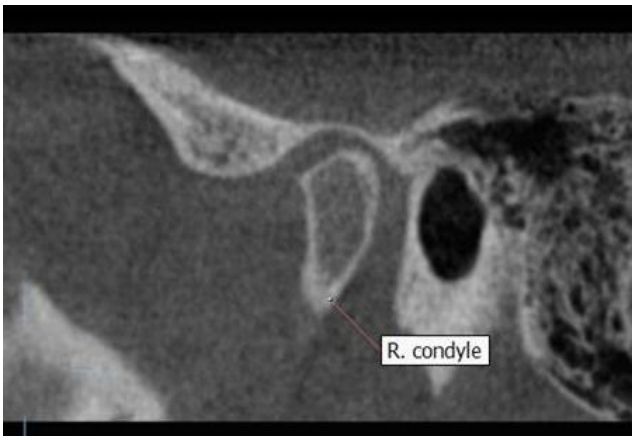


Figure 5a

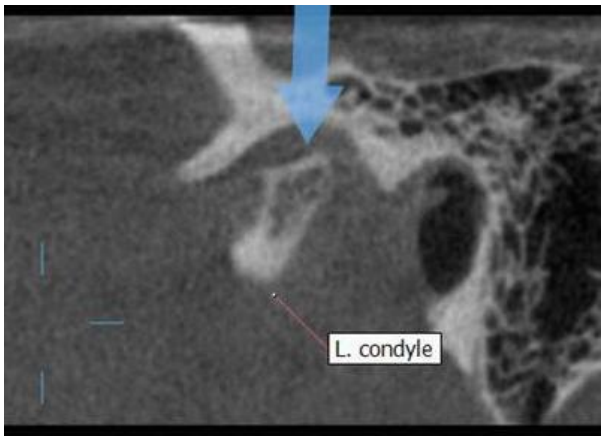


Figure 5b

Figures 5a and 5b. *Thin slice sagittal viewed showing a hypoplastic left condyle relative to the right.*

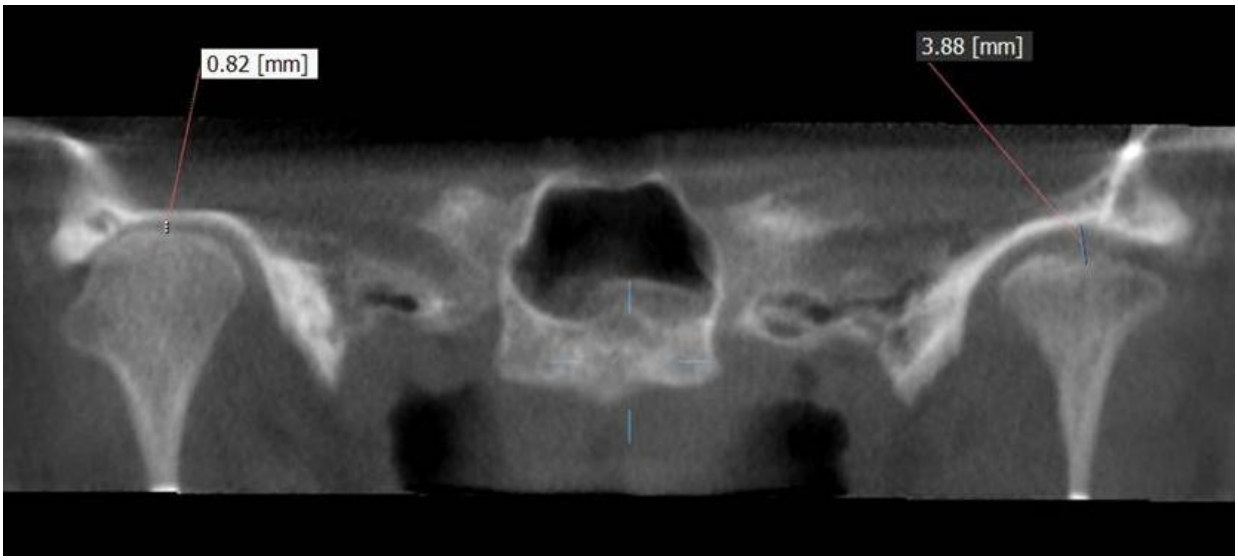


Figure 5c. *8.6 mm slice thickness showing hypoplastic left condylar head with a possible surface erosion. There also appears to be less joint space on the right.*

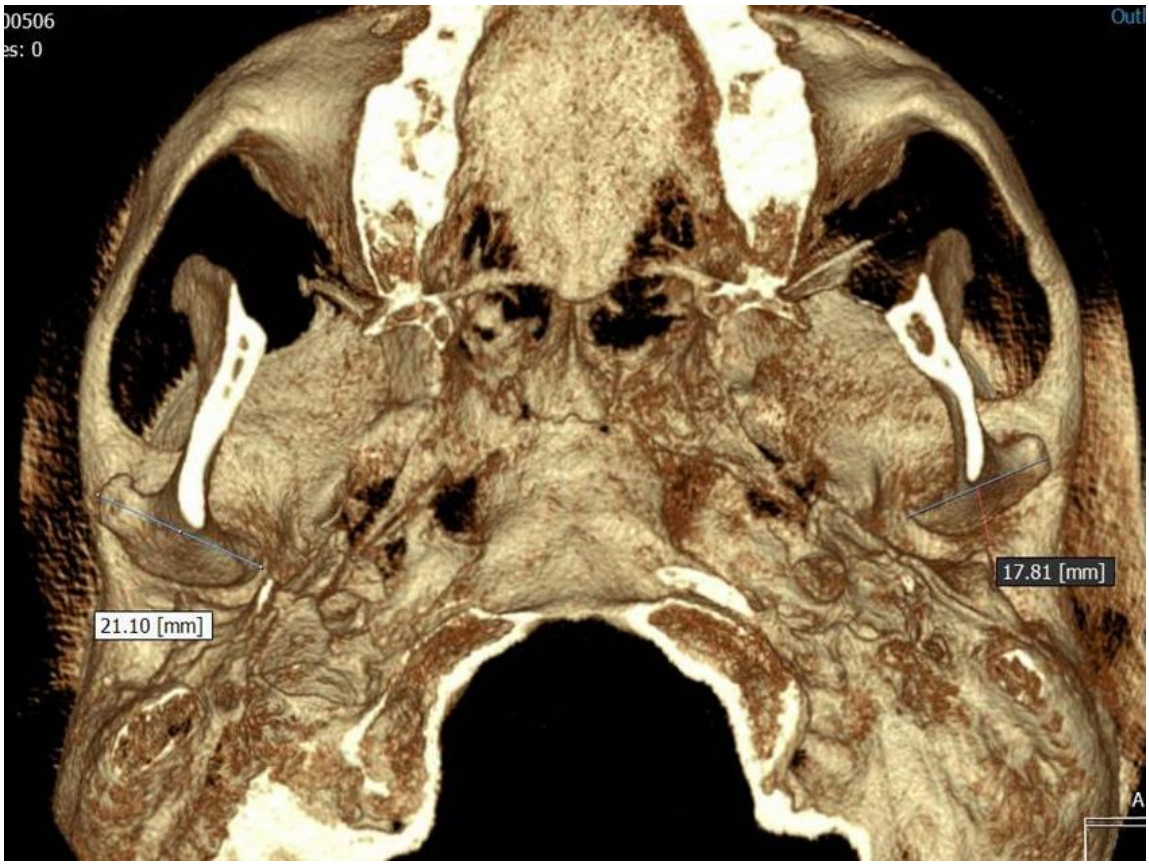


Figure 5d. *3-D color reconstructed view comparing the condylar heads. This was done in the slice thickness of about 40 mm. Measurements of the condylar with are within 0.1 millimeter accuracy.*

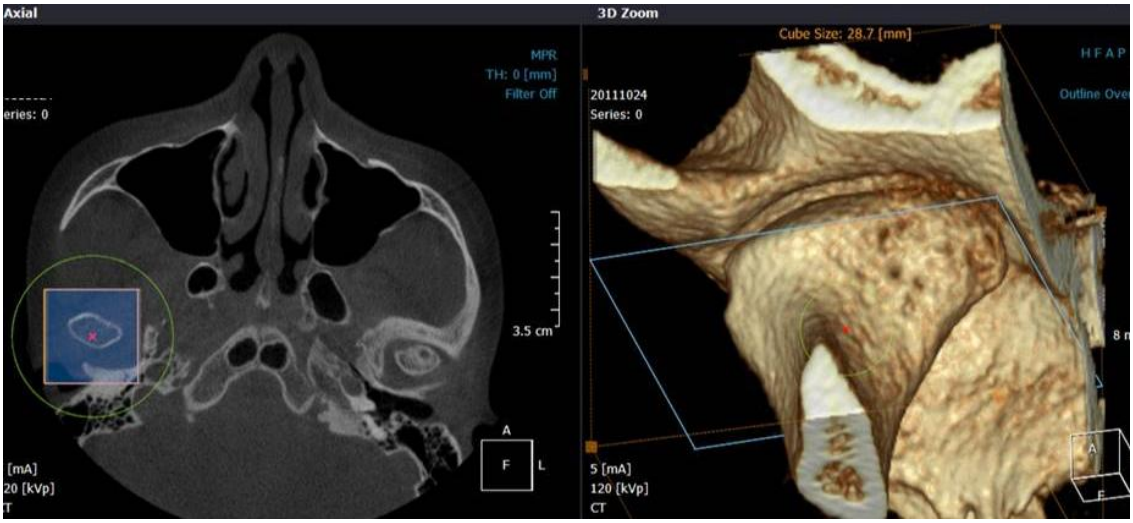


Figure 5e. *3-D color reconstructed view of another patient's right condyle. Note the subchondral cyst formation and subchondral sclerosis in the left condylar head in the axial slice on the left.*

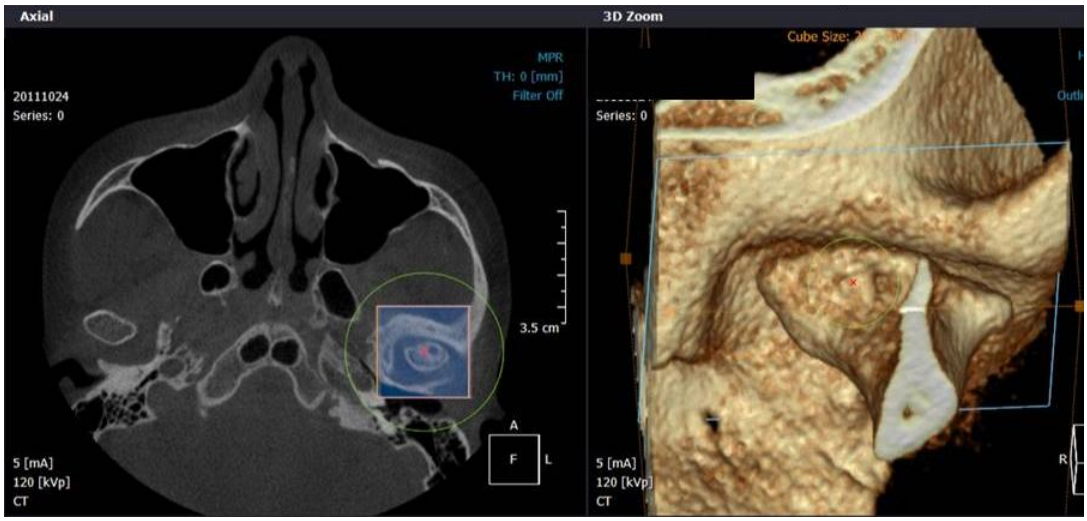


Figure 5f. *3-D color reconstructed view of the left condyle of the patient seen in figure 5e. This condyle is obviously remodeled and hypoplastic relative to the right.*

Figure 5g. *3-D color reconstructed panoramic view showing the hypoplastic left condyle. However, this was only part of the patient's hypoplasia problem, as the ramus is smaller in the posterior sending ramus a shorter. These changes would not be as apparent on a conventional panoramic image. Norwood the patient's periodontal bone loss be as easily assessed.*

Conclusion

As you can see from the examples above, and conditions such as osteoarthritis can be easily evaluated and visualized completely with thin gray scale multiplanar images, thickened slice data and 3-D color reconstruction. Almost all pathology can be evaluated or visualized as they really are within the patient. This visualization was unachievable with all previous imaging modalities used in dentistry. In addition we can make our terminology more precise when describing these changes because we can see the condyles in color in 3-D.

More complex situations such as the unilateral condylar hypoplasias seen above can also be easily visualized in easily compared using the many tools and features in third-party CBCT imaging software. If the clinical signs and symptoms warrant a CBCT evaluation of the patient, the clinician will be rewarded by easier visualization of the anatomy and pathology as well as more precise clinical decision-making because of the excellent images available with this imaging modality.

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