

Assessment of relative uptake by mandibular condyles in a “normal” population

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Abstract

Hyperplasia of the mandibular condyle is self-limiting, but can lead to facial asymmetry, malocclusion, pain, and dysfunction of the temporomandibular joint (TMJ). Bone scintigraphy, particularly with single photon emission computed tomography (SPECT), is effective in assessing relative condylar uptake, but we know of no standardised methods or values. Our aim, therefore was to validate the values currently used to measure relative condylar uptake in our population. Between December 2015 and June 2018 44 patients had skull SPECT (15 male and 29 female patients, whose ages ranged from 4–33 years). They were having bone scans (hydroxydiphosphonate (HDP) –^{99m}Tc, 740 MBq ev) for unrelated reasons and had no known abnormalities of the head, facial asymmetry, or symptoms of the TMJ. Two research workers measured the relative uptake between the condyles using the summed transaxial images. The Hospital Ethics Committee approved the investigation. The maximum difference in condylar uptake was 8.33% with research worker 1 and 8.77% with research worker 2, and the mean (SD) differences were 3.03 (0.17) % and 3.29 (0.18) %, respectively. Data were tested for normality, and the *t* test and one-way ANOVA were used to assess the significance of differences. None was found in total counts either between sexes or age groups, and there were none between the total counts measured by the two research workers. We conclude that our results are within the published ranges, and the variation in condylar uptake was less than 5% in 37/44 patients, and in none was it 9% or more. When the results indicate less than 10%, but there is a high clinical suspicion of active hyperplasia, surgeons should use their clinical judgement to decide whether condylar surgery is required.

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Introduction

Condylar hyperplasia of the mandible is self-limiting, but is known to lead to facial asymmetry, malocclusion, pain, and dysfunction of the temporomandibular joint (TMJ).^{1–6} Active growth may cease at any time, usually during puberty, but it

can continue for years, resulting in deformity.^{1,7} It can present at any age, but seems to be more common in young adults and (according to some authors) in women,^{3–6,8,9} though its pathophysiology is not yet fully understood.⁶ Persistent or resumed activity of prechondroblastic cells in the condylar growth zone, and endocrine disorders in which chondrocytes express growth factors, are some mechanisms that have been suggested as being responsible for the altered growth rate.^{1,2,5,6,9}

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Diagnosis can be made from clinical examination, radiographs, or nuclear medicine imaging. To choose the appropriate treatment and, if necessary, the type and timing of corrective surgery, it is crucial to differentiate active from inactive phases, particularly for patients with unilateral condylar hyperplasia.^{1,2,4,5}

Bone scintigraphy has been used for the diagnosis and planning of treatment of mandibular condylar hyperplasia for over 30 years.^{1,4,5,10,11} When ^{99m}Tc is labelled with disphosphonate it shows the uptake in the bone (either in physiological sites or in pathological osteoblastic lesions) proportionally to its metabolic activity.^{5,11} Different methods have been used, including planar imaging, 3-dimensional images with single photon emission computed tomography (SPECT) and, more recently, SPECT and positron emission tomography, though the latter two have not yet, to our knowledge, been validated.^{5,9,12,13}

Bone scintigraphy, particularly with SPECT, provides a more sensitive and accurate idea of condylar activity in growing and non-growing patients, as it is effective for the calculation of differences in condylar uptake, which reflects their relative growth rates.^{5,11,14} Different studies have shown a 5%–12% difference in uptake between normal condyles, with most referring to a 10% difference. However, there are no standard methods, either for quantification or for acquisition of the images.

Our aim, therefore, was to validate in our population the values that are currently used for the evaluation of relative condylar uptake.

Material and methods

We organised a prospective clinical study between December 2015 and April 2018 in which we took SPECT images of the skulls of 44 patients (29 female and 15 male; mean (SD) age 17 (9) years, range 4–33). They were having bone scans (HDP-^{99m}Tc, 740 MBq, ev) for clinically unrelated reasons, and had no known facial asymmetry or symptoms associated with the TMJ. A clinical examination was made by a nuclear medicine physician to exclude signs of condylar hyperplasia and other maxillofacial abnormalities before the acquisition. The Hospital Ethics Committee approved the trial, informed consent was obtained.

To compare uptake between the condyles we chose the method that was described by Hodder et al, and is the most commonly-used method.⁵

Two nuclear medicine physicians independently analysed the images. They reconstructed the acquisition of the SPECT, selected and summed all the transaxial images that included the condyles, drew a circular region of interest (ROI) over a condyle, and, finally, duplicated the ROI (to guarantee a fixed shape and number of pixels), by placing it over the other condyle. Total counts in each ROI were recorded, and the relative uptake was calculated as follows:

$$\text{Percentage of uptake in the right or left condyle} = (\text{right or left counts} / (\text{left counts} + \text{right counts})) \times 100.$$

Statistical analysis

We used the software Stata IC (version 15.1, Stata Corp). Data were tested for normality, and the significance of differences was assessed using Student's *t* test and one-way ANOVA. Cohen's kappa was calculated for inter-rater agreement.

Results

The largest differences in condylar uptake were 8.33% for research worker 1 and 8.77% for research worker 2. The mean (SD) differences were 3.03% (0.17) and 3.29% (0.18), respectively.

There were no significant differences in total counts between the sexes or age groups, and there was no significant difference between the total counts measured by the two research workers. Their percentage uptakes were classified into group 1 (0–5%), group 2 (5–10%), and group 3 (over 10%). Cohen's kappa was 0.78, which shows there was good agreement between them.

Discussion

The accurate evaluation of patients with suspected condylar hyperplasia is a crucial part of clinical decision-making. Treatment depends on the patient's age, severity of disease, and whether the condyle is still actively growing, in which case condylectomy is the preferred option. When growth has ceased, conventional orthognathic surgery is the preferred option.^{1–3,7,8,10,11}

Bone scans are widely used to assess growth, which helps with the diagnosis and selection of treatment. However, we found no published standardised methods or reference values for this evaluation. The first studies, which were published in the early 1980s, used planar imaging and qualitative evaluation.^{7,15,16} Since then many other studies have been published using various methods. More recently quantitative methods and SPECT images have been used, and these are currently the methods of choice.^{1–3,7,17}

Planar imaging has some limitations because of the superimposition of the condyles on other bony structures (petrous bone and the mastoid process). SPECT imaging can overcome this problem and permits a 3-dimensional reconstruction, better spatial resolution, and easier demarcation of the condyle.^{3,17} It is more accurate than planar imaging, with better sensitivity and specificity.^{2,3,7,10,15,18}

As far as quantification is concerned, procedural variations include uptake variables (total, mean, and maximum counts/pixel), the drawing criteria for the ROI (for example, whether the size is fixed or not), and the criteria for selection of slices (one slice or summed images).¹⁸ In addition, some

studies use an independent bony reference (L4 or the clivus, with planar or SPECT imaging, respectively) with which they compare each condyle.^{3,19,20} This method has not been validated, and has the drawback that it assumes that once growth has ceased the amount of uptake on the reference (normal) bone remains constant. However, it is well known that bony uptake can be altered for various reasons, including lumbar disease (trauma or even lordosis).^{7,17} The condylar comparison has better sensitivity (88%) than the condyle:clivus ratio (42%) or the condyle:lumbar ratio.^{4,21}

The most commonly used method (described by Hodder et al.⁵) is based on the total counts in each ROI, from which the comparison of uptake between condyles is calculated (relative percentage of the uptake of the isotope). Their findings were validated by postoperative follow-up, and the study is used as a reference for almost all other studies of condylar hyperplasia.³ They established that a 10% difference was the cut-off value for indicating if condylar growth had ceased, and if surgical intervention was required. Despite this 10% cut-off point, the maximum difference that they found in normal patients was 6%, and this has been reported before.^{3,8} Most of the other studies, however, evaluated patients with unilateral condylar hyperplasia and, though they reported different methods, quoted Hodder et al for the 10% cut-off value. For the ROI, the most sensitive and specific is an evaluation of the whole condyle.¹⁸ Based on this we also opted to calculate and compare uptake between condyles, as did Hodder et al.⁵

The results in our “normal” population are within the published range, and the variation in condylar uptake was less than 5% in 37/44 patients, and never equal to or more than 9%. When the results are less than 10%, but the clinical suspicion of active hyperplasia is high, surgeons use their clinical judgement to decide whether condylar surgery is required.

Conclusion

Bone scans are widely used to evaluate patients with suspected condylar hyperplasia, but neither methods nor values have been standardised. Our results are within the published range and provide support for the hypothesis that a difference in activity of 10% or more between condyles suggests abnormal turnover in the affected condyle compared with the other side. Most were less than 5%, which warrants further clinical investigation of the impact and importance of higher values. When the results are less than that but there is a clinical suspicion of active hyperplasia, surgeons should use their clinical judgement to decide if the patients would still benefit from surgical correction of the condyles.

Conflict of interest

We have no conflicts of interest.

Ethics statement/confirmation of patients' permission

The study was approved by the Hospital Ethics Committee. Patients' permission has been obtained.

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