Optimalization of quantification of mandibular growth

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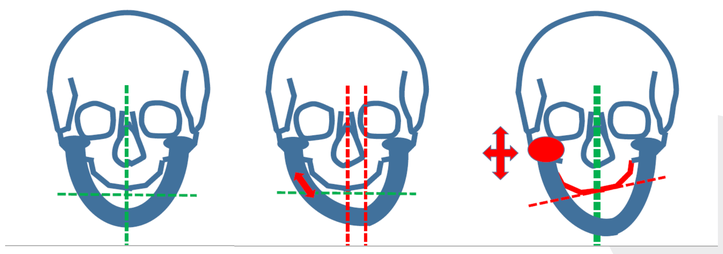
Purpose

Excessive growth of one condyle suspected of active unilateral condylar hyperplasia (UCH) may lead to asymmetric facial deformities and malocclusion. Single photon emission computed tomography (SPECT) bone scintigraphy is becoming current global standard for diagnostic of UCH. The examination is performed after intravenous administration of radioactive technetium-labelled diphosphates (^{99m}Tc-MDP). The aim of this research is to select the most suitable method for the evaluation of asymmetry and mandibular growth in comparison with the normal values.



Scheme of normal growth and UCH with hemimandibular elongation and UCH with hemimandibular hyperplasia.

Methods

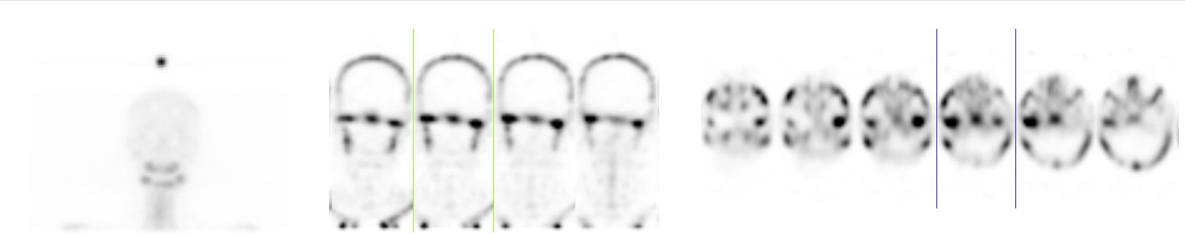
17 patients were evaluated (11 represent normal values, 6 patients with UCH). No patient from normal database had a previous history of growth abnormality or pathological condition involving the maxillofacial skeleton or mandible. These patients underwent an additional mandibular SPECT to create a normal database. Except the asymmetry, mandibular growth was also examined. The internal (clivus) and external standard (source of known activity) was used to evaluate the growth. The region and volume of interest (ROI/VOI) across each condyle and clivus were drawn by various methods. For each ROI/VOI, the total number of counts, maximum and average values in ROI/VOI and their size were recorded.

SPECT acquisition and reconstruction

Bone scintigraphy was performed 3-4 hours after administration. A 2 ml vial containing a known amount of ^{99m}Tc (350-600 kBq) was used as external standard and was placed above the patient's head.

The SPECT images were obtained on the dual-head Siemens Symbia S with LEHR collimators. The recovery coefficient curve was measured trough the Jaszczak phantom using micro and normal spheres and was made to select appropriate acquisition parameters in combination with the reconstruction parameters. The most appropriate acquisition mode was: matrix 128x128, step-and-shoot mode for 180 views per detector over 360° for 10 s per view. These data were reconstructed by iterative reconstruction of OSEM 3D with 4 subsets and 12 iterations using 7 mm Gaussian filter.

Additional whole-body scintigraphy was performed to ensure that growth zones are not present in another location.



Examples of scintigraphy images: scan with external standard (left image), coronal slices (middle image) and tranversal slices (right image).

External vs internal standard

Standardization of the condylar uptake values was considered to correct for differences in image timing, reconstruction, and the pharmacokinetic profiles of the tracer in each patient. There are two ways to simply correct these differences. The first is to compare the internal standard with the condyle. This standard was also considered to correct for variations in the volumes of distribution, bone metabolism, and renal clearance which may affect the plasma concentrations of tracer from the time of injection to the time of acquisition. Clivus was used as this standard.

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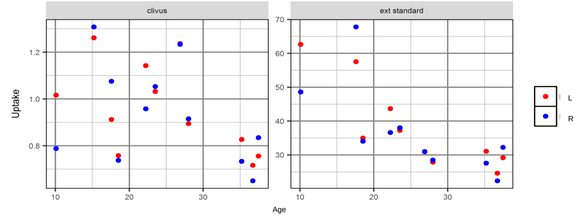
External vs internal standard

An external standard can be used, as discussed in Fahey et al., 2009. The external standard of known activity is in the field-of-view, preferably above the head. By determining the number of counts of standard, the calibration coefficient is obtained. This coefficient is needed to determine the accumulated activity in the condyle. Values from normal patient cases (not indicated of UCH) can be used to determine the mandibular growth, making it possible to determine whether the condylar growth in an asymmetric condyle has ceased or not.



Uptake as a function of age for mentioned method (3 ROIs, 25 pixels each)

Results & Discussion

Patients were evaluated by various methods, asymmetry and mandibular growth were determined based on the clinical experience of a physician. Mandibular growth was further investigated based on the presence of growth zones on whole-body bone scans.

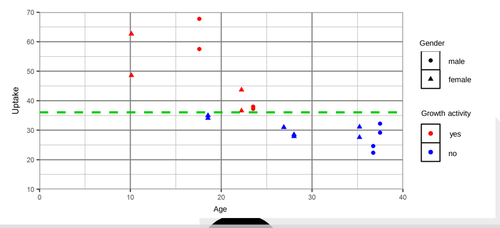
Asymmetry

The result of this analysis was the assessment of the most appropriate method for calculating asymmetry. Eleven patients from the dataset were selected, assuming a negative result of asymmetry (i.e. asymmetry ranging from 45 to 55%). The most appropriate method is the one with the most values at this interval. The best method were three ROIs above each other using average number of counts, each of 25 pixels (100% of the values within the interval).

External vs internal standard

For these methods, a comparison was made to evaluate the growth activity of the condyle depending on the age of the patient. Patients from the normal values dataset were selected and values were plotted for internal and external standardization over their age. To assess the mandibular growth more accurately, it is advantageous to have a more significant relationship between age and uptake in the condyle.

From this point of view, the most important method is method for external standardization. Another analysis was done to determine the interval for deciding whether the mandibular growth is present. To do this, an algorithm called the decision tree was used. Measured data is provided based on 3 ROIs, 25 pixels each (average counts) with external standardization. The decision limit for the presence of growth zones was set at 35.8. The decision tree further determined the age of the patient as an important variable but did not use it in the evaluation because only a small sample of data is tested.



Uptake as a function of age for mentioned method (3 ROIs, 25 pixels each) with decision limit for the presence of growth zones (35. 8).

Conclusions

At present, there is no gold standard for the diagnosis of UCH by nuclear medicine. In some cases, too early condylectomy or repeated surgery are wrongly performed due to incorrect assessment of mandibular growth. As in Rushinek et al., 2016, it is obvious that it is not appropriate to interpret results only from a separate SPECT, but it is necessary to use other clinical data. A whole-body bone scan showing growth zones that may not be visible on the SPECT of head appears to be a suitable additional evaluation.

It is obvious that the study was conducted on a small sample of patients and it is necessary to continue to examine it. It is beneficial to extend the normal values dataset and to cooperate more closely with dentist who would perform more detailed classification of the incoming patients and investigate them. However, even from such a small sample of patients, the most suitable method for assessing asymmetry and mandibular growth (with some restrictions) can be chosen. This study will be followed by a partial-volume and scatter corrections.

References

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