Reproducibility of morphological measurements and muscle DTI parameters in the masticatory system of healthy subjects.

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Introduction: The human masticatory system is highly complex, allowing a wide range of different movements. Temporomandibular disorder (TMD) is the most common painful condition of the masticatory system after toothache, but the underlying causes are not well understood and the effectiveness of current treatment is limited. As a result, there is significant interest in understanding the relationships between different elements of the masticatory system and medical imaging offers a promising approach to tackle this problem [1,2]. However, current literature shows limited consistency. This has been attributed to the fact that TMD is a multifactorial condition with a highly heterogeneous patient population. Furthermore, the duration of MRI sequences for masticatory imaging is often limited to approximately 8 min, requiring careful trade-offs between signal level and spatial accuracy. The aim of this study is to assess the reproducibility of measurements of bone and muscle morphology and muscle diffusion parameters within the masticatory system in healthy subjects.

Methods: Six right-handed young healthy female subjects (aged from 23 to 36 years) without prior history of masticatory system disorder, were scanned twice with a week apart. The scans were performed on a 3T whole body MRI system (Achieva TX, Philips Healthcare), using parallel transmission and 8 channel head/neck coil as receiver. The study was approved by the local ethics committee, and written informed consent was obtained prior to each scan.

Image Acquisition and Analysis: Each scan visit consisted of 2 anatomical scans (for bone and muscle) and one DTI scan.

Bone: T_1 weighted 3D MP RAGE sequence was performed with TE/TR 4.6/20 ms, voxel size 0.5×0.5×1 mm^3, 2 averages, flip angle 20°, FOV 230×198×100 mm^3, SENSE factor 1.5, scan time 4.5 min. The segmentation of the mandible was carried out in Avizo software, with landmarks positioned at standard anatomical landmarks (Figure 1). The ramus, condyle, mandibular body, lower mandible and upper mandible length were quantified by measuring the distance between corresponding landmarks (Figure 1). The same operator performed the positioning of landmarks and subsequent quantification on 3 separate occasions.

Muscle: T_2 weighted gradient echo and spin echo (GRASE) sequence was employed, with effective TE 56 ms, TR 5982 ms, FOV 230×198×100 mm^3, voxel size 0.3×0.3×1 mm^3, refocusing flip angle 150°, 3 averages, scan time 8 min. The same operator performed the muscle segmentation. The volumes of the masseter, lateral pterygoid and medial pterygoid muscles were subsequently measured.

DTI: Single shot DTI sequence was performed with *b*-value of 1000, 7 directions, voxel size 2×2×2 mm^3, FOV of 230×198×100 mm^3, 50 transverse slices, TE/TR 42/12800 ms, 5 averages, SENSE factor 2, scan time 8 min. DTI data was analysed in FSL software, with mean diffusitivity (MD) and fractional anisotropy (FA) volumes computed. Muscle segmentation results were downsampled and aligned to match the DTI resolution and muscle boundary. To avoid partial volume effect, masks were further eroded before they were applied to MD and FA maps to extract diffusion indices in each muscle group.

Statistical Analysis: Analysis was performed in SPSS software. The mean and standard deviation of each parameter were calculated by including both scan visits. Intraclass correlations (ICC) were performed between the two visits to derive ICC coefficient (ICCC). The percentage fractional error (PFE) was computed as the difference between the two visits divided by the mean, and subsequently the root mean squared (rms) values were calculated.

Results: A typical 3D-rendered segmentation result is shown in Figure 2. The absolute value of PFE is shown in Figure 3, where each dot represents the measured parameter of a subject with the distance to the centre representing PFE.

Discussion: The bone measurements are highly reproducible with ICCC in the range of 0.864-0.980. Muscle volume reproducibility is related to muscle volume, as the two smaller muscles, medial and lateral pterygoids, show less reproducibility. This is also reflected in diffusion parameters, where only masseter diffusion parameters are reproducible. In addition, masticatory muscles are likely to be affected by physical activity prior to the scan (e.g. differences in chewing forces between subjects due to dietary differences), which may contribute to the lower reproducibility compared to the bone. The deep location of medial and lateral pterygoids compared to the more superficially located masseter may also contribute to the potential signal dropout, and lower reproducibility in MD and FA in these muscles.

Conclusion: Clinical studies assessing masticatory function should perform careful power calculations to ensure the validity of findings.

References: [1] Ng HP, *Dentomaxillofac. Radiol*., 2009; [2] Shiraishi T, *Acta Radiology*, 2011

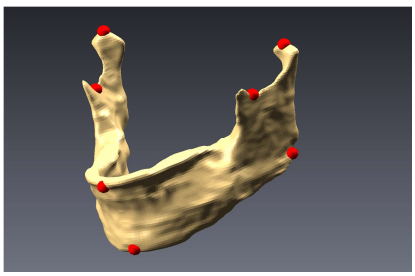

Figure 1: Bone Morphology

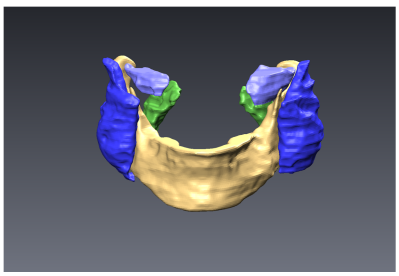

Figure 2: Muscle Morphology

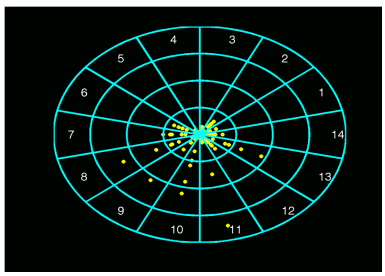

Figure 3: PFE Distribution

1. Ramus Height
2. Condyle Height
3. Mandibular Len
4. Low Mandible Len
5. Up Mandible Len
6. Masseter Vol.
7. Med. Pterygoid Vol.
8. Lat. Pterygoid Vol.
9. Masseter MD
10. Med. Pterygoid MD
11. Lat. Pterygoid MD
12. Masseter FA
13. Med Pterygoid FA
14. Lat Pterygoid FA