

Radiographic Evaluation of the Carpometacarpal Joint in Early Stage Osteoarthritis Severity and Joint Laxity

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INTRODUCTION

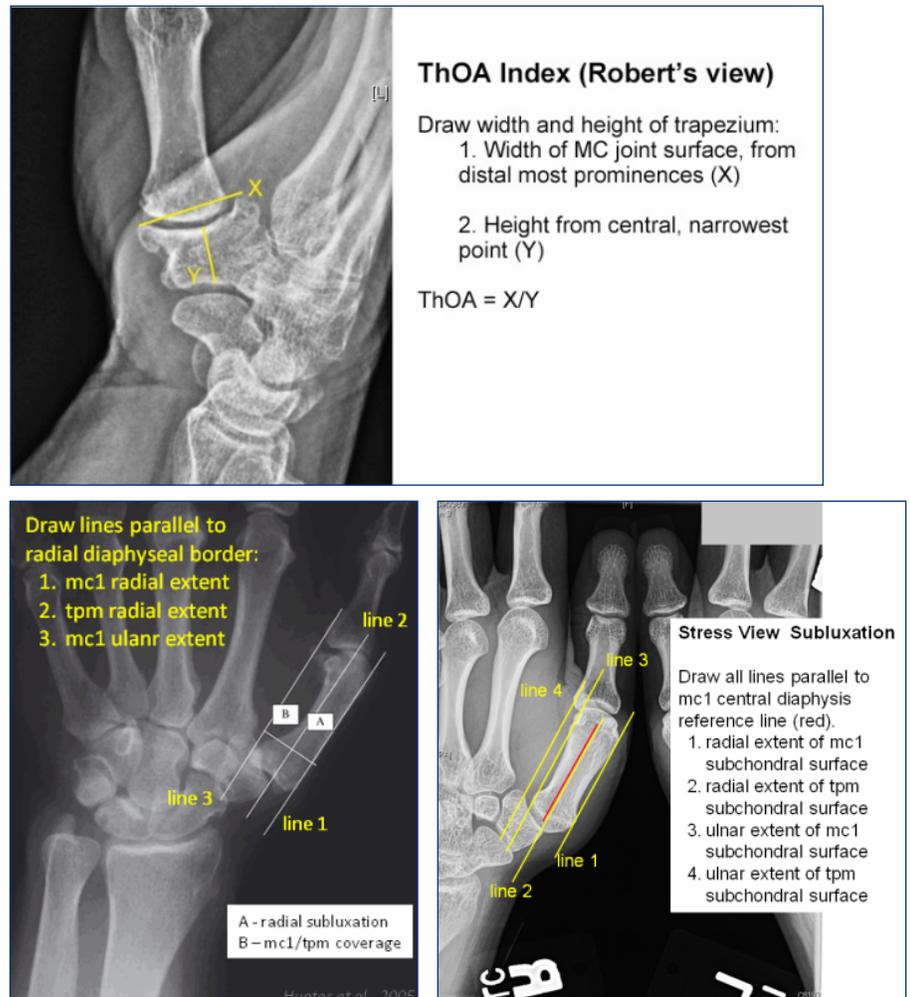
Thumb carpometacarpal osteoarthritis is a common and disabling disorder that affects 15% of adults over the age of 30, and 66% of women over the age of 55.¹ Thumb use is affected by pain, weakness and loss of dexterity, leading to significant impairment (40%-50%)² of the upper extremity due to its central role in nearly all grasp and handling maneuvers. Since Kellgren and Lawrence's study documented the prevalence of degenerative thumb CMC arthritis in the late 1950s³, several subsequent studies have confirmed the importance of accurate radiographic evaluation in the grading of OA across assorted radiographic views. However, widely used OA staging systems are of questionable utility, as they are highly subjective and unreliable between users. The present study will generate heretofore unavailable foundational data on longitudinal and quantitative evaluations of CMC joint subluxation and ThOA (thumb osteoarthritis) indices through key radiographs. In a sample of patients who present with pain and Eaton Stage I/II joint degeneration, radiographic OA progression at 1.5- and 3-year follow-up was expected to be more advanced in patients with larger baseline CMC joint laxity than in those with smaller baseline CMC joint laxity and in those with no evidence of OA.

Four fundamental radiographs (lateral view, Robert's view, posteroanterior view, and stress view) were obtained for each subject. A total of 139 (69 normal, 70 OA) subjects were imaged, and data was sent to orthopaedic surgeons, residents, and CMC radiologists. An ImageJ macro was developed that allows raters to grade OA progression using the Eaton and Ladd-Weiss classification systems and digitally calibrate the radiographs to perform the preceding measurements. In the Robert's view radiograph, Thumb Osteoarthritis index (ThOA) was determined by the ratio of the measured trapezium width to the measured trapezium height. In the lateral view, Hunter radial subluxation (RS) of the base of the first metacarpal off the trapezium and Hunter metacarpal 1-tpm coverage (mc1-tpm), the amount of the base of the first metacarpal covering the articular surface of the trapezium, were quantified.

Subsequently, the stress view radial subluxation, articular width (AW) of the metacarpal, and distance (U) between the ulnar articular facet of the trapezium and the ulnar metacarpal edge measurements were performed for both hands in the stress radiograph. In addition to longitudinal data that is currently being collected and processed, reproducibility among and within users (1 biomedical engineering student, 1 medical student) was also evaluated. Intraclass correlation coefficients were calculated for inter-user reliability (with 95% confidence interval) and test re-test bivariate analyses for intrauser reliability (with $p < 0.05$).

Statistical analyses using SPSS software of the Eaton and Ladd-Weiss gradings demonstrated significant inter- and intra-user variance. The intraclass correlation coefficient (ICC) was fairly low (ICC=0.392, 95% C.I.) and test-retest

Figures (counterclockwise): Robert's view, Hunter's view, Stress view



coefficients ($r=0.197-0.304$, $p<0.05$) as well. In Robert's view, the interclass correlation coefficient (ICC=0.883) for the ThOA index measurements exhibited high agreement, as did the test-retest reliability coefficient ($r=0.723-0.984$). In the posteroanterior view, raters calibrated the Hunter RS and Hunter mc1-tpm measurements, which translated to a RS/ mc1-tpm ratio of 0.35 (standard deviation = 0.017). Intraclass correlation coefficient (ICC=0.819) and test-retest reliability ($r=0.702-0.930$) for the ratio confirmed acceptable reproducibility. In the stress view, raters measured RS, AW, and U for both right and left hands, which yielded an average right hand RS/AW ratio of 0.48 (SD= 0.011). Intraclass coefficient (ICC=0.746) and test-retest reliability ($r=0.603-0.799$) were moderate for the right thumb. Moreover, the left RS/AW ratio of 0.46 (SD=0.008) had higher inter- (ICC=0.813) and intra- ($r=0.699-0.923$) user reliability. High ICC and r values indicate high fidelity and reliability in this quantified paradigm for defining subluxation and, consequently, OA progression. These results are highly contributive due to the demonstrated consistency of radiographic evaluations, in contrast to the variability in existing classification systems. Such findings facilitate better diagnoses and correlate

clinical CMC symptoms to a systematic radiographic standard. Longitudinal data from benchmark year 0 and progression of OA patients at year 1.5 will also be presented at the time of the conference.

The findings from the present study on thumb CMC biomechanics and OA progression will foster the development of new clinical treatment techniques to arrest early stage disease progression. The improvement of radiographic CMC joint analysis and, in particular, quantifying the ThOA index and joint subluxation informs the assessment of degenerative radiographic changes and the detection of subluxation to preventatively reduce risk of osteoarthritis.

References

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