UCSF score: a novel quantitative assessment score for cartilage lesions in early osteoarthritis - data from the osteoarthritis initiative

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Purpose

• MRI based semi-quantitative scoring systems such as Whole-Organ Magnetic Resonance Imaging Score (WORMS) and Boston-Leeds Osteoarthritis Knee Score (BLOKS) have been established for quantification of morphological changes associated with knee osteoarthritis (OA).

• These scores are, however, limited for measuring progression of cartilage lesions in early stages of OA.

The purpose of this study was

1. to describe a novel quantitative scoring system for cartilage lesions (UCSF score).
2. to determine the new score’s reliability
3. to determine the new score’s clinical validity.
4. to compare with WORMS and BLOKS in terms of detection of cartilage defect progression.

Methods and Materials

Research subjects:

• 47 individuals with risk factors for Osteoarthritis
• 25 individuals without risk factors for Osteoarthritis

Inclusion Criteria

• Age: 45-55
• BMI:19-27 kg/m²
• WOMAC score of zero: no knee pain in either knee
• Kellgren Lawrence (KL) Score # 1 at Baseline

Imaging Techniques

• Baseline and 24 month follow-up right knee 3T MR images
• Sequences available for interpretation:
  • sagittal intermediate weighted fat-saturated turbo-spin echo
  • 3D water excitation double-echo steady state
  • coronal intermediate weighted turbo-spin echo.

IMAGE ANALYSIS-
Baseline and 24 month follow-up images were analyzed by two radiologists using **WORMS, BLOKS and UCSF Score** for quantification of cartilage defects.

- A 3 week interval between analyses using each scoring system (washout period).
- Radiologists blinded to patient information (including OAI Cohort)
- Cartilage defects graded in 6 Compartments (Patella, Medial Femur, Medial Tibia, Lateral Femur, Lateral Tibia)
- Signal inhomogeneity was NOT graded

**Semi Quantitative Morphological Grading**

**A. Whole-Organ Magnetic Resonance Imaging Score (WORMS)**

- Modified WORMS used to grade cartilage (6 compartments instead of 15)

**B. Boston-Leeds Osteoarthritis Knee Score (BLOKS)**

- Cartilage "1" score performed in same 6 compartments. Assigns 2 separate scores for:
  - (i) each BLOKS subregion for the areal extent of any cartilage loss
  - (ii) for the percentage of subregion surface area which has full thickness loss

**C. Quantitative Morphological Grading (UCSF SCORE)**

- The UCSF score essentially calculates the volume of cartilage defects (WORMS grade>2)
- the extent of visible cartilage defects is quantified by multiplying five features of the lesion

**UCSF Score = largest diameter (mm) x number of sections x section thickness including gap (mm) x depth x shape factor**

**Reliability**

10 studies were analyzed twice by 2 radiologists using UCSF score, in order to assess intra- and inter-reader reliability. Weighted Kappa Values were calculated for individual features of the UCSF Score while Intraclass Coefficient (ICC) was calculated for the total UCSF score.

**Statistics**
The progression measured with the 3 scoring systems was compared using multilevel, mixed-effect linear regression models.

**Fig. 1:** UCSF Score; definition of depth and shape scores as well as diameter. Depth: (A) superficial lesion (less than 50% deep) is given a score of 1; (B) more than 50% deep lesion is scored as 2 and (C) full thickness lesion as 3. Shape: if maximum depth occupies less than 50% of the lesion (D), it is scored as 0.5, otherwise as 1 (E). Diameter: largest Diameter is measured (F).
Results

**Baseline Subject Characteristics**

- The mean age of the normal subject cohort \( n = 25 \) was \( 51.1 \pm 2.6 \) years and the mean BMI was \( 23.4 \pm 2.1 \) (kg/m\(^2\))
- The mean age of the subjects with risk factors for OA \( n = 47 \) was \( 51.5 \pm 3.5 \) years and the mean BMI was \( 24.1 \pm 2.1 \) (kg/m\(^2\))
- No significant difference between the two subject groups in terms of age and BMI \( p<0.05 \)
- Of the 25 individuals without risk OA factors 20 (80%) were female, while 27 (57%) of subjects with risk factors for OA were female.

**Quantitative and Semi-quantitative Assessment of Cartilage Lesions**

- Overall 432 compartments of the knee were studied.
- At baseline, a total of 24 compartments (16.0%) in normal subjects without OA risk factors and 84 compartments (29.8%) in subjects with OA risk factors had cartilage lesions.

**Sensitivity to Progression for Quantitative vs. Semi-Quantitative Scoring Systems**

- When assessing the progression across all compartments in all subjects with and without OA risk factors, 51% of the lesions analyzed with the UCSF score progressed while 18% progressed with WORMS and 13% with BLOKS.
- The UCSF score was found to have a higher sensitivity for cartilage lesion progression than both the WORMS and the BLOKS \( p<0.0001 \).
- The difference between BLOKS and WORMS regarding measurement of progression was not significant \( p= 0.101 \).

**Reproducibility of UCSF Score**

- Intraclass coefficient correlations calculated for intra- and inter-observer agreement of the quantitative analysis of images based on UCSF score were 0.86 and 0.91
- Figure 5 comprises the intra and inter-observer Cohen's kappa measurements for the individual features of the UCSF Score.
- All features demonstrated excellent reproducibility with interobserver kappa values ranging from 0.87 to 0.94; shape factor and diameter measurements had the highest level of agreement.

**Clinical Validity of UCSF Score**
• Using UCSF Score, the subjects with risk factors had significantly higher odds ratios of progression than subjects without risk factors (OR 2.78 (1.36-5.7), p=0.005).

• With WORMS Scoring, the difference in detection of progression between the subjects with and subjects without OA risk factors was not significant (OR 1.44 (0.40-5.13), P=0.571).

• Using BLOKS Score, the subjects with risk factors did not have significantly different odds of progression than subjects without risk factors (OR 7.09 (0.92-54.6) p=0.060). Poor sensitivity to progression explains the high odds ratio; BLOKS score detected very little progression only in the subjects with risk factors and no progression in normal subjects, which explains why no significant results were found.

Images for this section:
**Fig. 4:** Patellar Lesion Progressed at 24-month follow-up (A, C) from Baseline (B, D), as measured using UCSF Score, but not WORMS or BLOKS

**Fig. 2:** The UCSF Score detected significantly more progression than the BLOKS and the WORMS in all subjects. There was no significant difference between the BLOKS and the WORMS in terms of detection of cartilage defects.
The intra- and inter reliability for the total UCSF score were calculated as ICC of **0.91 & 0.86**

**Table 1. Weighted Kappa Values for individual features of the UCSF Score**

<table>
<thead>
<tr>
<th>UCSF Score Feature</th>
<th>Intra-observer agreement</th>
<th>Inter-observer agreement</th>
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</thead>
<tbody>
<tr>
<td>Largest Diameter</td>
<td>0.91</td>
<td>0.93</td>
</tr>
<tr>
<td>Depth</td>
<td>0.89</td>
<td>0.81</td>
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<tr>
<td>Shape Factor</td>
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<td>0.94</td>
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<tr>
<td>Number of Sections</td>
<td>0.88</td>
<td>0.87</td>
</tr>
</tbody>
</table>

**Fig. 5:** Reproducibility with weighted Kappa Values for individual features of the UCSF Score
**Fig. 3:** UCSF Score detected more progression of cartilage lesions, over a period of 2 years than BLOKS and WORMS in all compartments of the knee except for the Medial Tibia
Conclusion

- The UCSF Score is a novel reproducible and valid quantitative scoring system for cartilage lesions, which provides an improved detection rate for monitoring cartilage lesion progression, compared to the semi-quantitative WORMS and BLOKS.
- Early recognition of progression makes it an important tool with applications in both the clinical setting and for scientific studies, in particular for early OA.
- The United States Food and Drug Administration (FDA) still recommends joint-space narrowing on radiographs in addition to pain and function, as co-primary end points to establish the effectiveness of OA disease-modifying drugs. A more sensitive MR based technique such as the UCSF score may be better for examining the effectiveness of therapeutic interventions.

References


Personal Information

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