DOES THE TRADITIONAL TT-TG DISTANCE ACCURATELY REFLECT THE RELATIVE POSITION OF THE TIBIAL TUBERCLE TO THE TROCHLEAR GROOVE?

Navya Dandu MD, Tristan J Elias BA, Erik Haneberg BS, Mario Hevesi MD PhD, Kevin T Credille BSE, Zachary Wang BS, Nozomu Inoue MD PhD, Adam B. Yanke MD PhD

1. Rush University Medical Center, Chicago IL 60612

MIDWEST ORTHOPAEDICS AT RUSH

BACKGROUND

- The tibial tubercle to trochlear groove (TT-TG) distance is one of the most frequently used metrics to evaluate patients with patellar instability

- Several issues have been proposed with the use of the traditional TT-TG measurement, including inconsistency between readers and compounding effect of severe trochlear dysplasia on reliability, with conflicting results in literature

PURPOSE

The objective of this study was to compare the traditional TT-TG distances to novel three-dimensional measures generated from automated trochlear groove detection with sequential radial cuts, and to determine the correlation of these measurements to common clinical examination findings in patellar instability patients.

HYPOTHESIS:

We hypothesized that the three-dimensional measurements would differ from the traditional measurements, and furthermore the offset between the tibial tubercle and trochlear groove would vary through flexion

METHODS

Study Design

- This study was comprised of a retrospective arm and prospective arm for recruitment of healthy control subjects.
- For the retrospective arm, a review of subjects was performed to identify patients with a diagnosis of patellar instability at a single institution from 2017 to 2021. Inclusion criteria consisted of a confirmed history of at least one lateral patellar dislocation event as well as referral for MRI for evaluation of injury related to the dislocation event.
- The prospective arm was conducted by recruitment of healthy volunteer subjects to undergo MRI of an unaffected knee

Three-Dimensional Modeling

- TT-TG distances were measured by two independent graders, and the average was considered the final traditional distance
- All patients were categorized into a Dejour dysplasia grade
- All knee MRIs were segmented into 3D models using medical segmentation software (Materialise Mimics)
- A custom-written program was designed for model analysis
- A three-dimensional radial or polar axis was established by the distal femoral condyles around the transepicondylar axis.
- Automated detection of the trochlear groove surface was performed by identifying points at each radial degree Automated detection of the tibial tubercle center of mass was employed and the surface projection of that point was utilized.

Analysis

- The point radial TT-TG (rTT-TG) was determined as the medial-lateral distance between the tibial tubercle center of mass and the trochlear groove point (x-axis) at 104° on the radial axis (determined by the radial angle at which a trochlear groove entrance point was placed on axial MRI).
- the Maximum rTT-TG was defined as the maximum medial-lateral distance within the set of 45 degrees.
- These two measurements were compared against the traditional TT-TG for each dysplasia grade
- These three measures were also compared between different grades of physical examination (J sign present/absent, and flexion angle at which instability disappears)
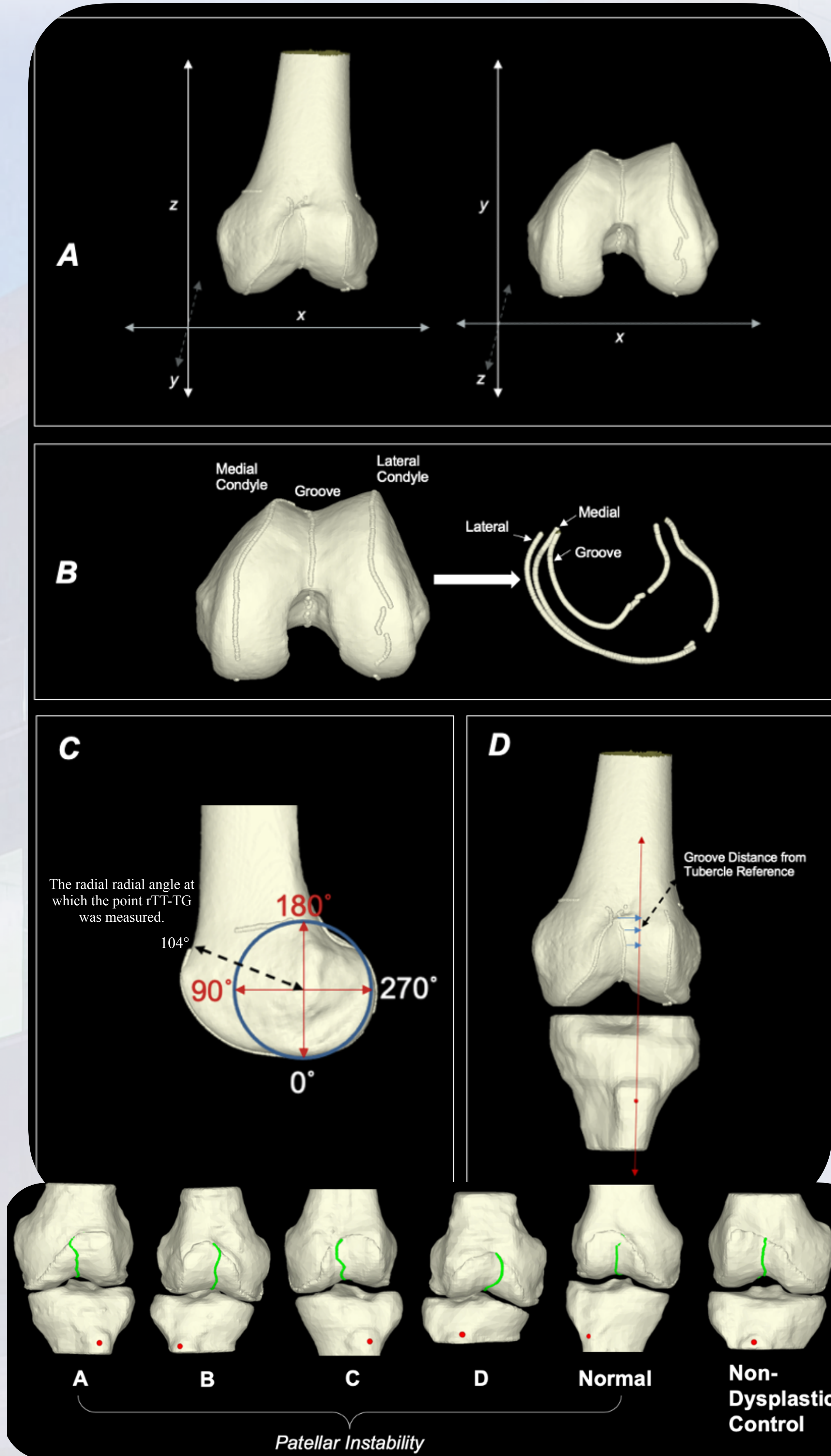

Figure 1. TOP: (A) Demonstration of XYZ axis establishment relative to 3D femur models, (B) automated groove and condyle detection, (C) radial axis, and (D) illustration of sequential radial distances to tibial tubercle landmark. BOTTOM: Sample of groove morphology per each group included in the study
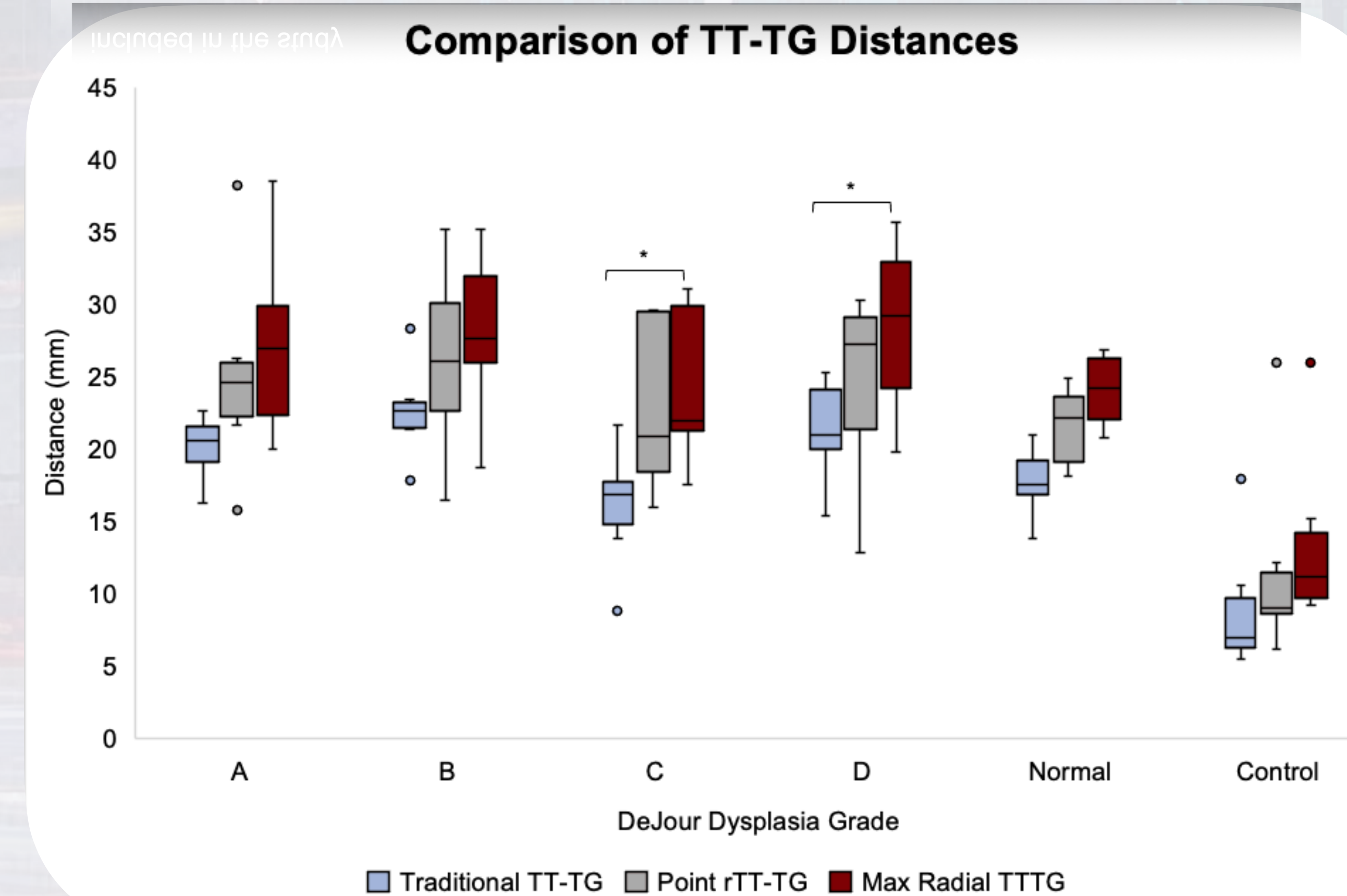

Figure 2. Comparison of three different TT-TG measurements (1 traditional and 2 radial) separated by dysplasia grade and patellar instability status. Significant differences were identified primarily in higher grades of dysplasia.

RESULTS

Radial versus Traditional TT-TG

- Across all subgroups, the point and maximum rTT-TG distances were greater than the traditional TT-TG distance.

- Within the Dysplasia C group, the maximum rTT-TG (24.7 ± 5.5) was significantly greater than the traditional TT-TG (16.1 ± 4.0, p=0.047), but non-significantly different from the point rTT-TG (23.2 ± 6.1, p=0.69). In the Dysplasia D group, the maximum rTT-TG (28.4 ± 6.0) was greater than the traditional TT-TG (21.4 ± 3.5, p = 0.047), but non-significantly different from the point rTT-TG (24.5 ± 6.7, p=0.59).

Physical Examination

- Patients with a flexion instability angle > 60 demonstrated significantly greater point (p=0.02) and maximum rTT-TG distances (p=0.01), but equivalent traditional TT-TG distances (p=0.62)

- Presence of a J-sign was associated with a greater point rTT-TG (p=0.047), but non-significant maximum rTT-TG (p=0.08) and traditional TT-TG (p=0.77). There were no significant differences in traditional (p=0.47), maximum (p=0.36), or point distances (p=0.32) for apprehension.
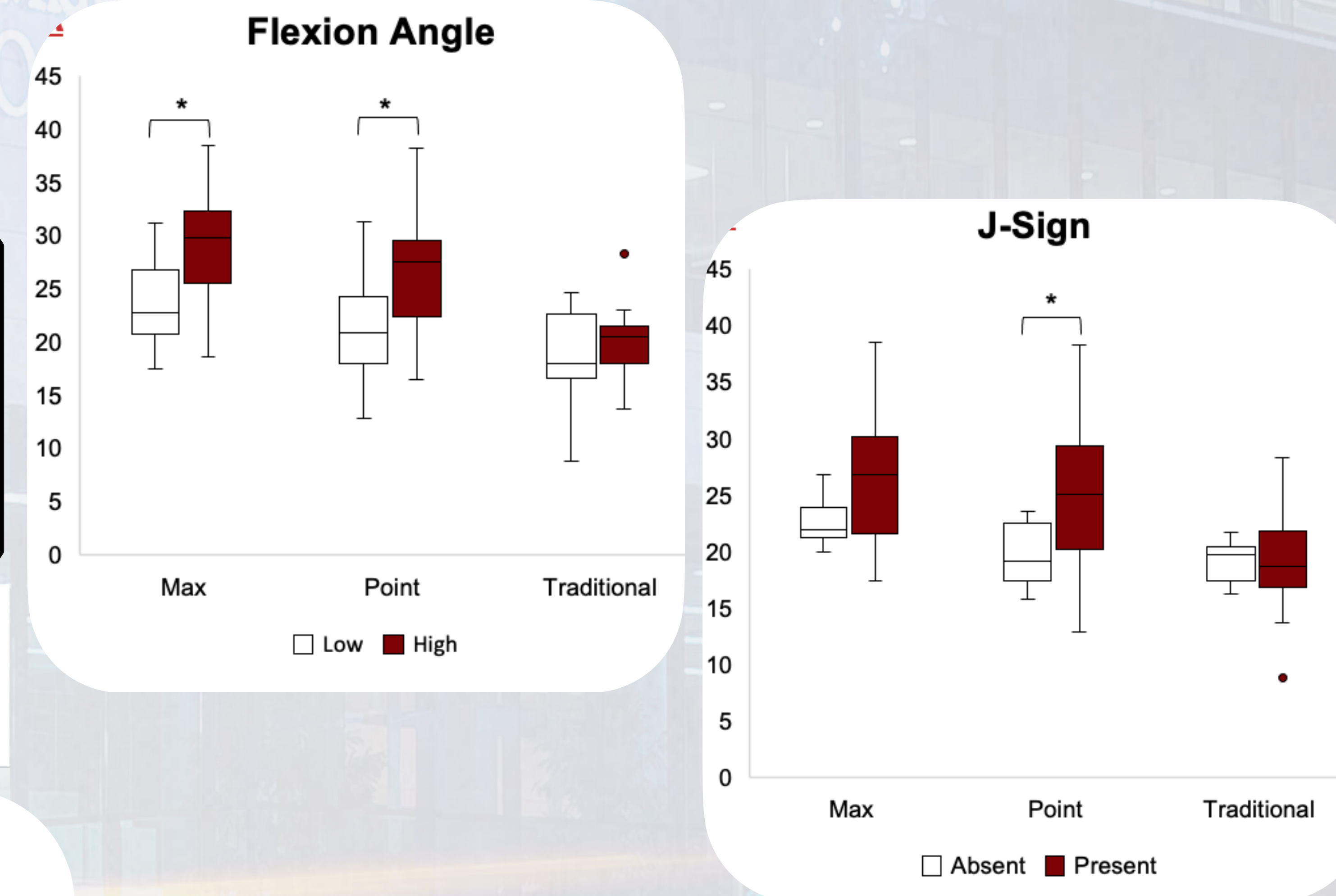

Figure 3. Comparison of radial and traditional TT-TG measurements between different physical examination signs, demonstrating association between radial measurements, presence of a J-sign, and higher flexion angle of instability. Traditional measurements did not correlate with these physical examination findings.

CONCLUSION

- Traditional TT-TG measurements performed on MRI may underestimate the true lateral offset of the tibial tubercle relative to the trochlear groove, particularly in the setting of severe dysplasia (Dejour C and D)
- Radial-based measurements may better correlate with severity of physical examination findings than the traditional TT-TG distance.
- Automated detection of the trochlear groove and tibial tubercle on three-dimensional models represents a feasible methodology for standardization of clinical assessment and surgical planning.