

# Coronal Tibiofemoral Subluxation in Knee Osteoarthritis

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## Introduction

Knee osteoarthritis (OA) is a leading cause of disability associated with high health care costs. Impaired load transmission through the tibiofemoral joint is an important variable related to knee OA progression.<sup>1</sup> One factor contributing to impaired load transmission and knee OA that is less commonly studied is coronal tibiofemoral (CTF) subluxation. CTF subluxation is a potentially important radiographic finding; previous studies have shown that CTF is related to poor Western Ontario and McMaster Universities (WOMAC) pain score,<sup>2</sup> tibial spine impingement on the femoral condyle,<sup>3</sup> and is a possible reason for unexplained pain following unicondylar knee arthroplasty. However, the published data

regarding CTF subluxation is limited, and commonly used OA grading systems such as the Kellgren-Lawrence classification do not account for the degree of CTF subluxation when assessing knee OA. In fact, we are not aware of any studies in the English literature which evaluates CTF subluxation in knee OA.

The purpose of the study was therefore to analyze knees in varying stages of OA for the presence and the severity of CTF subluxation.

## Methods

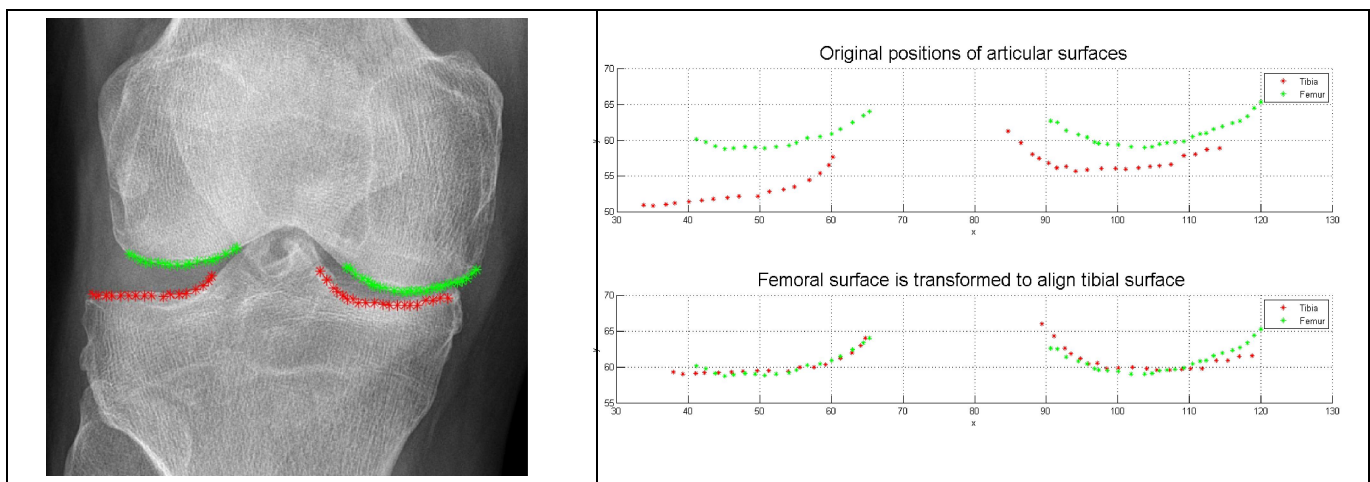
We retrospectively evaluated CTF subluxation in 113 knee weight bearing radiographs of patients with different stages of knee osteoarthritis (OA) who were being considered for an arthroplasty procedure. For simplicity, knee OA was classified as “Mild” or “Severe” according to Kellgren-Lawrence scale, stages 1-2 were considered as “mild” and stages 3-4 were considered as “Severe”. For evaluation of CTF subluxation in normal healthy group, we used the ,routinely performed, both limbs standing radiographs of patients younger than 40 years who underwent anterior cruciate ligaments reconstructions and had no complaints in the contralateral knee.

Since the tibiofemoral joint lacks anatomic landmarks which enable accurate measurement of CTF subluxation, a new measuring software code (Matlab, MathWorks Inc., Natick, MA, 2012) based on the Iterative Closest Point (ICP) mathematical algorithm was developed. The specially developed software enables digitization of distal femur and proximal tibial articular surfaces and represents them as the two scattered clouds of points. The software code includes also an ICP algorithm which seeks to minimize the sum of the square distances between these two clouds of points, and attempts to find the rigid transformation

(translation and rotation) that best aligns them (Figure 1) . By aligning the articular surfaces into optimal position, the CTF subluxation was measured as an isolated parameter. The new method for CTF subluxation measurement was validated using cadaveric knees and published in a previous study. <sup>4</sup>

CTF subluxation was measured in the controls and in the study groups using the new special software code. In addition, lower limb alignment was measured using hip to ankle standing radiographs in both groups.

Figure 1



## Results

Mean CTF subluxation in the control group was 1.4 % (  $\pm 1$  ) of the tibial plateau. However, mean CTF subluxation in the “Mild OA” and “Severe OA” groups was 3.5 % (  $\pm 2$  ) and 3.5% (  $\pm 5$  ) of the tibial plateau, respectively. For both the “mild” and “severe” OA groups. CTF subluxation was significantly increased compared to the CTF subluxation in the control, (  $p <$

0.0001) and ( $p = 0.012$ ), respectively. There was no significant difference in CTF subluxation between the “Mild OA” and “Severe OA” groups ( $p = 0.75$ ). Lower limb alignment in the control group was  $1^\circ (\pm 0.7)$ , in the “Mild OA” group it was  $3.6^\circ (\pm 2.2)$  and in the “Severe OA”  $5.3^\circ (\pm 2.6)$ . The alignment in both OA groups was significantly higher comparing to the control group, and in the “Severe OA” group comparing to the “Mild OA” group ( $p = 0.0003$ ).

## Discussion and Conclusions

Our data suggests that CTF subluxation is a radiographic finding related to knee OA, it occurs mainly in the early stages of the osteoarthritic process, perhaps when the soft tissues around knee still have some inherent laxity. However, in severe knee OA the soft tissues stiffness and ankylotic changes around the knee prevent further CTF subluxation. In addition, we showed, as reported in previous studies, that lower limb malalignment is an ongoing process throughout all the various stages of OA which may contribute to OA progression.<sup>5</sup> In the current study we used a highly precise and unique method based on ICP algorithm for CTF subluxation measurement<sup>4</sup> and evaluated for CTF subluxation in different stages of knee OA. Further studies should be conducted for a deeper understanding of CFT subluxation and to reveal the clinical consequences related to this finding.

## References

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