

# Can the Contralateral Knee Effectively Estimate Pre-Injury Patellar Height? A Control Study

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## ABSTRACT

**Introduction:** Patellar height abnormalities have been associated with patellar instability, which is common among adolescents and young adults. Pre-injury patellar height is often unknown in patients with a patellar instability episode. The purpose of this study was to determine whether patellar height of one knee could effectively estimate patellar height of the contralateral knee in control patients between the ages of 13 and 25 years.

**Methods:** A retrospective chart review was conducted to identify 40 patients who obtained bilateral knee radiographs with no prior surgical intervention or diagnosis of injury to the extensor mechanism. Caton-Deschamps Index (CDI) was measured by three different examiners on two separate occasions. Inter- and intra-observer intraclass correlation coefficients (ICCs) were calculated, and mean side-to-side difference was calculated between left and right CDI measurements. Additionally, left and right means were compared, and 95% confidence intervals were calculated.

**Results:** Intra-observer reliability of ICCs were good to excellent among all examiners (0.92, 0.91, and 0.86), and inter-observer reliability was good at 0.85. Mean CDI side-to-side difference was 0.02 (95% confidence interval 0.05, -0.01). Average CDI ratios were left knee CDI of 1.10 and right knee CDI of 1.12.

**Conclusions:** Good to excellent inter- and intra-observer reliability was demonstrated. There was no difference found between left and right knee CDI measurements. These results confirm that patellar height measurements in one knee can reliably estimate the patellar height in the other knee in patients between the ages of 13 and 25

**Keywords:** Patellofemoral Joint, Patellar Ligament, Patellar Dislocation, Joint Instability, Adolescent

## INTRODUCTION

Patellar height is a measurement of the location of the patella in relation to the knee joint line, and increased patellar height (ie, patella alta) has been associated with

patellar instability.<sup>1</sup> Patellar instability is a topic that has received considerable attention in sports-medicine studies in the last few years, as the popularity of medial patellofemoral ligament reconstruction (MPFL) has increased. Patellar instability is most common in the 10- to 17-year-old population, and the incidence of patellar instability within this group is estimated to fall between 29 to 31 cases per 100,000 people, with 30 to 60% of these patients sustaining recurrent dislocations.<sup>2-5</sup> Recent studies have shown a decrease in patellar height after isolated MPFL reconstruction without any associated tibial tubercle distalization procedures.<sup>2</sup>

There are various methods for measuring patellar height. The most commonly used methods are the Insall-Salvati ratio, the modified Insall-Salvati ratio, the Caton-Deschamps index (CDI), and the Blackburne-Peel ratio.<sup>6</sup> The CDI method is highly reproducible, validated in the pediatric population, reliable in patients 9 years and older, and reflective of postsurgical changes of tibial tubercle distalization procedures.<sup>7</sup> Thus the authors prefer the CDI method for assessing patellar height.

Patellar ossification begins between 6 to 8 years of age and completed by 16 to 17 years of age, making assessment of patellar height particularly difficult in young children. Previous studies have shown that the normative CDI range for patients who are 12 years and older is unchanged from adult range, with normal values between 1.3 and 0.6.<sup>8</sup>

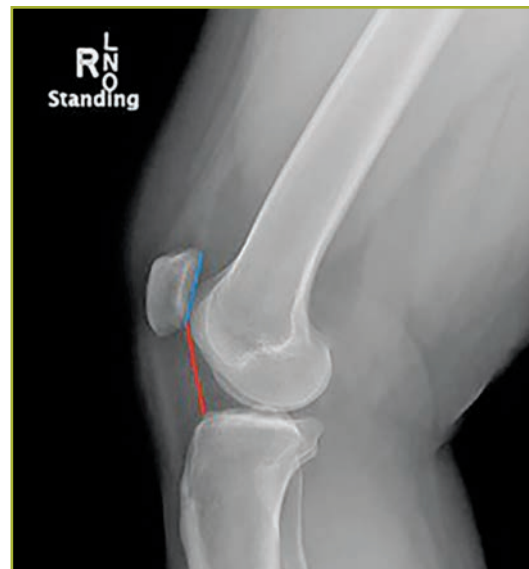
The pre-injury patellar height in children who sustain episodes of patellar instability remains unknown, because it is unlikely for these children to have pre-injury radiographs of the injured knee. The contralateral knee may serve as a surrogate marker for pre-injury patellar height. Previous work by Berg et al<sup>6</sup> showed inconsistency among side-to-side patellar height comparisons in adult patients; however, the majority of these patients had osteoarthritic changes that may have affected the accuracy of measurements. The purpose of our study was to 1) examine the reliability of patellar height measurements in adolescent patients without

significant osteoarthritic changes, and 2) assess for differences in side-to-side patellar height among these patients. We hypothesized that the contralateral knee can be used to accurately estimate the patellar height for the knee of interest in adolescent patients, providing a surrogate marker of pre-injury patellar height in patients with patellar instability. Additionally, we hypothesized that patellar height measurements using CDI can accurately and reproducibly be obtained by medical trainees of varying experience.

## METHODS

We received approval from our Human Research Review Committee (HRRRC #18-159). Forty patients' radiology records were obtained at our institution's pediatric and adult orthopaedic clinic over the course of 2 years. We reviewed patients presenting with bilateral knee pain and no history of trauma. A priori power analysis was conducted to determine a sample size of 40 patients based on a 95% confidence interval for the difference in patellar height of two side-to-side uninjured knees. Radiographs and patient charts were reviewed. Patients were included in the study if they were between the ages of 13 to 25 at the time of radiographic assessment, with bilateral knee sports series radiographs (weight bearing anteroposterior, lateral, sunrise, and notch view) available. The age of 13 years was chosen as the lower limit of our study population based on previous research that found reliable measurements of CDI with similar mean values to adults at the age of 12 years or greater.<sup>1</sup> The age of 25 years was chosen as the upper age limit to mirror the population most at risk for patellar dislocation and to minimize exposure to radiographic evidence of osteoarthritis.<sup>4</sup> Our standard sports series radiographs include a weight-bearing lateral x-ray with the knee in 30° of flexion, and these lateral radiographs were used for measurement of CDI. The CDI was chosen over other patellar height measurements because its validation in pediatric patients, good to excellent inter- and intra-observer reliability, and ability to reflect post-surgical changes of distalization procedures, which are all commonly performed in patients with patellar instability.<sup>1,6,9</sup> Exclusion criteria for our study included patients with radiographic evidence of osteoarthritic changes (Kellgren-Lawrence grade > 0)<sup>10</sup>; history of patellar dislocation; previous surgical intervention to either knee; acute or chronic injury to the extensor mechanism, including quadriceps or patellar tendon rupture, patella fracture, Osgood-Schlatter Disease, or Sinding-Larsen-Johansson Syndrome; acute injury with resulting knee joint effusion; or any evidence of ligamentous instability on clinical examination by an independent pediatric surgeon or sports-medicine, fellowship-trained orthopaedic surgeon.

All radiographs were measured by three examiners who were not involved in the care of the patients. The three examiners were a medical student, orthopaedic surgery resident, and an orthopaedic surgery, sports-medicine fellow. Measurements of the CDI were



**Figure 1.** Lateral knee weight bearing radiograph at approximately 30° flexion showing Caton Deschamps Index (CDI) measurements with red line A representing distance from inferior articular surface of patella to the anterior aspect of the tibial plateau, and blue line B representing distance from superior to inferior articular surface of patella. CDI ratio = A/B.

conducted, as described by Caton et al,<sup>11</sup> as the distance from the inferior aspect of the articular surface of the patella to the most proximal anterior portion of the tibia, divided by the distance from the superior to the inferior aspect of the articular surface of the patella (Figure 1). All measurements were obtained using Philips Intellispace PACS (Philips Healthcare, Cambridge, Massachusetts). Right and left knees were measured independently by all 3 examiners, and each knee was measured on two separate occasions by each examiner. To avoid biasing measurements, there was at least one week between measurements.

All measurements of the de-identified data for each examiner were assessed for intra-observer reliability using an intraclass correlation coefficient (ICC). Additionally, the average of the two measurements for each knee was used to calculate inter-observer reliability using ICCs. The measurements were rated in accordance with previously defined standards as poor (ICC < 0.5), moderate (ICC 0.5-0.75), good (ICC 0.75-0.90), and excellent (ICC > 0.90).<sup>12</sup> All measurements for each knee were averaged, and the side-to-side CDI difference was obtained for each patient. For the entire cohort, mean difference in side-to-side knee CDIs was calculated with a 95% confidence interval. All statistical analysis was conducted with Microsoft Excel (Microsoft Corporation, Redmond, Washington).

## RESULTS

Of the 40 patients enrolled in the study, there were 27 young women and 13 young men, some of whom were adolescent. The mean age of the enrolled patients was 17.7 years old, with ages ranging from 13 to 25 years.

Patellar height measurements varied between 0.83 and 1.37, with a mean CDI of 1.11 (95% CI 1.08 - 1.14).

Reliability of the CDI measurement within our patient population was tested with intra-observer and inter-observer ICCs. Intra-observer reliability, as calculated with ICCs, was good to excellent for all examiners. The sports-medicine fellow had an ICC of 0.92, the resident had an ICC of 0.91, and the medical student had an ICC of 0.86. Inter-observer reliability was also good with ICC of 0.85.

Side-to-side patellar height comparison was evaluated using mean difference of CDI between left and right knees for each patient. The mean side-to-side CDI difference for all patients was 0.02, with a 95% confidence interval (0.05, -0.01). The mean CDI of the left knee and right knees were 1.10 and 1.12, respectively. Each patient's mean side-to-side CDI difference was examined, and 22 of the 40 patients showed an absolute mean side-to-side CDI difference of less than 0.05. A total of 90% of the patients showed an absolute mean side-to-side CDI difference of less than 0.15. A histogram showing the distribution of mean side-to-side CDI difference was created, which shows a normal distribution centered at 0 (Figure 2).

## DISCUSSION

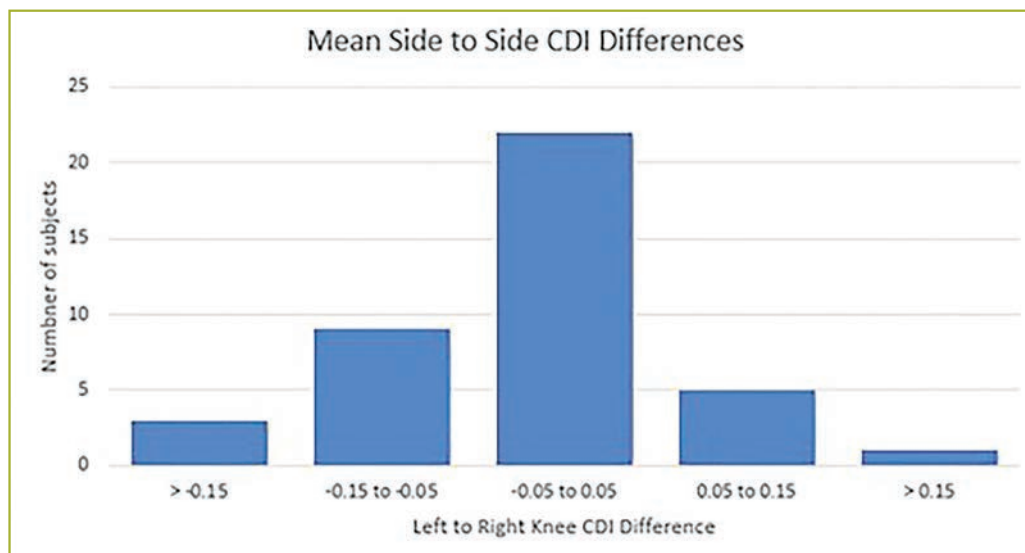
Our results show that patellar height can accurately be measured in children and adolescents without radiographic signs of osteoarthritis, and there is very little variation in patellar height measurements between sides. This proves that one knee can reliably estimate the patellar height of the other knee.

Patellar height, or patella alta, has been associated with recurrent patellar instability. Appropriate treatment of patients with recurrent patellar instability requires a detailed assessment of the patient's anatomic and predisposing risk factors, including patellar height, tibial tubercle to trochlear groove distance, limb alignment, patellar tilt, and trochlear dysplasia.<sup>9,13,14</sup> Previous studies

have shown that an isolated MPFL reconstruction will decrease patellar height. However, it is not known whether MPFL reconstruction restores the patellar height to normal, or if it risks overconstraining the patellofemoral joint. Additionally, whether the patellar height is affected by an acute MPFL tear remains unknown at this point. We plan to conduct future research to see if patients with a first-time dislocation have an increased patellar height in comparison to their uninjured knees.

Our overall mean CDI value of 1.11 is similar to those seen in the adolescent population, with one previous study showing an average CDI of 1.07 for patients between the ages of 12 to 15 years.<sup>1</sup> Our average was slightly higher than the 0.97 presented by Berg et al<sup>6</sup>. This may be due to differences in patient population, given that our patient population was younger and lacked arthritic changes, specifically proximal patellar pole osteophytes. Additionally, the majority of our patients were diagnosed with bilateral patellofemoral pain syndrome, and thus may have a slightly higher CDI than the general population. Although this is a potential limitation of our study, it is likely a closer representation of the at-risk patient population for recurrent patellar instability.

In their study, Berg et al<sup>6</sup> found a side-to-side mean CDI difference of 0.16, which is far greater than our side-to-side difference of 0.02. Berg et al<sup>6</sup> included adult patients, and it is possible that patellar and tibial osteophytes affected the accuracy of the measurements. This suggests that the contralateral knee may not serve as an appropriate control in adult patients with arthritic changes, but in adolescent and young adult patients without arthritic changes, the contralateral knee provides an effective and accurate estimate of the patellar height of the other knee.



**Figure 2.** Histogram of mean side-to-side differences in patellar height with normal distribution centered at 0.

These findings are important for future work that examines the effect of knee injuries on patellar height. Additionally, this work proves that the contralateral knee can be used for estimation of pre-injury patellar height in the injured knee. This research will allow future investigations to determine whether patellar dislocation increases patellar height. Previous research has shown MPFL reconstruction decreases patellar height, but it is unknown if this is reestablishing the anatomic patellar height, or overconstraining the patellofemoral joint. Future work building on this study will aim to quantify the presence or absence of change in patellar height associated with first time lateral patellar dislocation.

This study has several limitations, including the inability to extrapolate these results to patients outside of our 13- to 25-year-old age group and those with radiographic signs of arthritis. Our patient population primarily had diagnoses of patellofemoral pain syndrome and may not truly represent the anatomic structure of the uninjured general population. However, given that our study population was primarily pediatric patients and young adults, we felt that this group closely resembled patellar instability patients and also avoided patients with additional radiation exposure. Additionally, a large proportion of our patients were skeletally immature, and considering their remaining growth potential, it is possible that this may result in future changes to their patellar height with continued growth. This was taken into account in study design, and only patients 13 years of age or greater were enrolled, as previous studies have shown no change in CDI ratios between skeletally mature patients and skeletally immature patients 12 years of age or greater.<sup>1</sup> This age group is also at the greatest risk of patellar instability. For this reason, skeletally immature patients aged 13 and greater were included for generalizability of future work. Finally, there was inherent variability in the quality of the lateral weight-bearing 30° flexion radiographs obtained, and this may have affected the accuracy of our measurements.

This study shows no side-to-side differences in patellar height between knees in adolescent and young adult patients. The study supports the use of the contralateral knee as a control for estimating patellar height in this patient population. Additionally, our results show that the CDI can accurately and precisely be calculated by trainees of all levels.

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