Correlation of Gait Analysis with Lower Limb Torsional Profile: Clinical and Radiological Findings in a Large Case Series of Paediatric Patients with Chronic Patello-Femoral Joint Instability

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INTRODUCTION:

The incidence and diagnosis of patello-femoral joint (PFJ) instability in the paediatric population is rapidly increasing. Atraumatic PFJ instability is often due to a combination of factors such as structural bone and joint abnormalities, soft tissue irregularities and muscle imbalances. Due to a lack of consensus in the surgical management of paediatric PFJ instability and the large number of patients presenting with long standing, complex, atraumatic PFJ instability to our centre, we developed a multi-disciplinary approach to their management, utilising data from clinical assessment, gait lab analysis and computed tomography (CT). Whilst enabling the best intervention for patients, this MDT approach improves our understanding of this condition. This study reports on a large number of cases of paediatric PFJ instability and shares important signs detected from clinical assessment, gait analysis and CT.

METHODS:

50 Paediatric patients ≤18 years old, referred with longstanding PFJ instability between 2021-2024, were included in this study if they had undergone both gait lab analysis and CT rotational profile. The inclusion criteria was further limited to: PFJ extension instability, atraumatic and no resolution of symptoms with at least 6 months of physiotherapy.

CT rotational profile measurements were carried out by two independent raters. Femoral version was calculated through the neck-horizontal angle and the condyle horizontal angle. Tibial version was calculated proximally from the posterior tibial axis and distally through the transmalleolar axis and talar axis. The combined femur and tibia version (i.e. lower limb version) was calculated once by adding the femoral version to the tibial version referencing from the transmalleolar axis and once via the talar axis. Gait analysis was carried out in the same lab, with the same gait lab specialists for all patients and included electromyography (EMG) of the lower limb muscle groups.

RESULTS:

50 paediatric patients (100 limbs) with PFJ instability were identified, with an average age of 15 years at the time of gait analysis. 54% were males.

CT rotational profile showed a range of femoral version from -8.7° to 62.7°. Tibial version ranged between 9.7° and 67.4° using the transmalleolar axis and 8.1° and 56.7° using the talar axis. The overall lower limb version ranged from -32.7° to 49.2° using the transmalleolar axis and -33.8° to 34.2° with the talar axis. There was no statistically significant difference between the 2 rater's measurements ($p>0.05$).

Comparison of the CT combined lower limb version and gait analysis showed a statistically significant difference between the ankle rotation during stance phase and CT combined lower limb version calculated with the transmalleolar axis (p value <0.0001, 95% CI). However, when the CT combined lower limb version was calculated with the position of the talus in the mortise, no statistically significant difference was found (95% CI), indicating it as reliable radiographic measurement of the foot progression angle and closely mimicking the clinical presentation and highlighting its superiority in surgical planning for torsional alignment.

During the gait cycle 77% showed mild ankle plantar flexion on initiation of stance phase (heel strike), rather than ankle dorsiflexion. 94% initiated stance phase with the knee in extension (up to 10 degrees), rather than initiating heel strike with the knee in mild flexion.

DISCUSSION AND CONCLUSION:

Previous gait analysis in PFJ instability has commonly shown decreased gait velocity and cadence and more attention was given to how PFJ instability functionally affects the patient. This study has shown subtle altered gait patterns in children with chronic, atraumatic PFJ instability who have been able to compensate for their gait velocity and cadence over time. This primarily results in keeping the knee in extension and the ipsilateral ankle in slight plantar flexion upon initiation of stance phase. This is likely a protective measure as this gait pattern allows the patient to transition from heel strike to foot flat (mid-stance) with minimal knee flexion-extension movement, decreasing the PFJ subluxation sensation.

Interestingly, this study found a difference in tibial version and ankle position when using the transmalleolar axis or talar angle to carry out calculations. Using the talar angle correlated well with the foot progression angle and can be used reliably between CT and gait analysis.

In conclusion, the understanding and analysis of gait in a pathological setting, such as PFJ instability is highly complex due to variables involved such as: lower limb alignment, proprioception, pelvis and spinal anatomy, as well as deconditioning of lower limb muscles. Our study would strongly recommend the use of gait analysis, as well as CT rotational profile in the assessment and surgical planning for management of longstanding, atraumatic PFJ instability in the paediatric population. Future work is focussing on post operative gait analysis.