

# Femoral torsion evaluation by computed tomography in a young Brazilian population with hip pain and femoroacetabular impingement<sup>\*</sup>

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## ABSTRACT

**Introduction:** The aim of the study was to evaluate femoral torsion (FT) by computed tomography (CT) in young patients with hip pain and femoroacetabular impingement (FAI) in a Brazilian population. After the diagnosis of impingement, the complete analysis from the hip biomechanics and morphology has become essential.

**Methods:** Forty-one patients from 18 to 45 years presenting hip pain without arthrosis (Tönnis < 2) were evaluated by CT scan from February 2017 to February 2018. All patients presented hip pain for at least 3 months and FAI. They have followed the same radiographic protocol and modified Harris Hip Score (mHHS) evaluation. Statistical analyses by software R version 3.4.4. with significance  $p < 0,05$ .

**Results:** After exclusion criterias, twenty-six patients (9 bilateral) were included, mostly man (73%). The average age was 35 years for both genders. BMI was 19 kg/m<sup>2</sup> for women and 24 kg/m<sup>2</sup> for men and the mean modified Harris Hip Score was 67 points. We have found femoral torsion changes in 11 hips with pain (31%) and high variability (60%). The mean FT was 14,5°, ranging from 0 to 39°. Patients with hip pain, CAM impingement and altered FT had no correlation when compared to controls (without pain) ( $p = 0.234$ ), neither Mixed impingement ( $p = 0.314$ ). Patients with Pincer impingement and painful hips had higher FT (16,63°) than controls (11,77°) ( $p = 0.045$ ). **Conclusion:** The presence of torsional alterations in almost 1/3 of the patients with FAI and the high variability reveal the importance of measuring FT at this disease.

## 1. Introduction

Femoral torsion (FT) is defined as the angle formed between the posterior transverse line of the distal femoral condyles (knee joint) in relation to an imaginary line formed by the base of the neck and the center of the femoral head. Normal values range from 5° to 25°, with an average around 15°, but it may vary.<sup>1–3</sup> It is known that the femoral head is usually directed superiorly, ventrally and medially.<sup>3</sup> The femoral rotation occurs mainly over its axis (torsion) almost exclusively at the proximal region of the femur, above the lesser trochanter.<sup>4</sup>

At birth, FT has increased values, ranging from 30° to 40°, which decreases over the years.<sup>3</sup> This angle is important in the diagnosis and evaluation of various pathologies, such as hip dysplasia, lower limb

rotation deformities like toe in and toe out, cerebral palsy and in selected patients with indications for surgical corrections, such as osteotomies for femoral rotation correction or arthroplasty, in cases of severe osteoarthritis.<sup>5–7</sup> Although the influence of femoral torsion in hip diseases is not a recent subject, studies are still contradictory regarding the injury caused by larger or smaller angles.<sup>8</sup> The angular adjustment between the femoral head and the acetabulum influences the hip joint biomechanics.<sup>9–12</sup>

Femoroacetabular impingement (FAI) translates a dynamic conflict between femoral head and the acetabulum, divided in three types: CAM impingement, when there is an absence of sphericity in the femoral head-neck junction; pincer type, when the acetabulum provides excessive coverage over the femoral head; and mixed type, which is the

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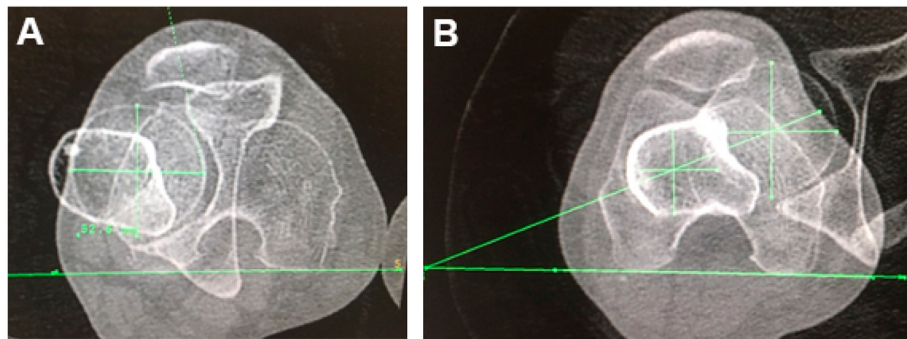


**Fig. 1.** Computed tomography (2 right hips) with overlapping images for calculating femoral torsion: (A) Abnormal femoral torsion (retrotorsion); (B) normal femoral torsion.

combination of both types of impingement, being considered the most common in most studies.<sup>6,7,9–11</sup> With a better understanding of FAI, it was finally possible to identify the main cause of hip osteoarthritis, with a concept based primarily on movement, rather than axial load, and is modernly characterized as a syndrome that encompasses both clinical and radiological signs.<sup>12</sup> Recent studies evaluating femoral torsion comparing its results with other hip biomechanical parameters have been performed in essentially Caucasian populations or Asian.<sup>4,5,8,11,12</sup> Brazil has a multiethnic population with proven genetic miscegenation, which makes this assessment unprecedented, with interesting results when compared to other studies in genetically less complex populations in terms of genetic variability.<sup>13</sup>

## 2. Methods

### 2.1. Study design and patient

After the approval by the Research Ethics Committee, forty-one young patients with hip pain who spontaneously attended for evaluation were included. All had hip pain for at least 3 months and ages between 18 and 45 years, evaluated from February 2017 to February 2018. Inclusion criteria were patients who had hip pain, age between 18 and 45 years old, accepted to participate in the study (signing the informed consent), skeletal maturity (Risser V score), physical examination compatible with FAI symptoms, performed a complete standardized radiographic evaluation recommended and without hip osteoarthritis (Tönnis classification < 2).<sup>7</sup> The exclusion criteria applied to the patients were: other secondary diseases of the hip (such as osteonecrosis, dysplasia, etc.), previous limbs surgeries and angular changes (coxae vara or valga). Patients with suspected rheumatologic diseases, who had pain in small joints for more than 6 weeks were referred for diagnostic investigation of inflammatory diseases according to the criteria recommended by the American Academy of Rheumatology.<sup>14</sup> Patients with other sources of pain such as lumbar spine, trochanteric region and deep gluteus, which could have confounding factors were excluded. Other patients at risk of radiation exposure, such as pregnant women and patients after neoplastic diseases, were also excluded. From the 41 selected patients, fifteen were excluded for the following reasons: one (01) patient had an unfavorable and rapid evolution to severe osteoarthritis; two (02) patients dropped out of the study afraid of a possible surgery indication; four (04) patients did not have only FAI, with associated angular changes; eight (08) patients did not return with the requested images. Therefore, twenty-six patients were included, nine of whom had bilateral pain, and the analysis was performed on 35 painful hips and compared to 17 painless contralateral hips (control group). All patients underwent the same specific clinical and radiological evaluation, as well as having their data recorded individually. Signs and symptoms considered to characterize impingement syndrome were: hip pain on rising after prolonged sitting periods; pain

during or after moderate impact physical activity (such as running); presence of positive “C” sign (pain poorly located in the hip region); pain at passive examination of the hip flexion joint at 90° associated with internal rotation to a degree less than 15° or pain during active joint exams such as active flexion against resistance or leg roll. All patients had their weight and height measurements assessed on a certified scale for the calculation of body mass index (BMI) and were also evaluated by the modified Harris Hip Score (mHHS), which has been translated and validated for the Portuguese language spoken in Brazil.<sup>15</sup>

### 2.2. Data collection

Radiographic images were ordered through a standardized application and delivered to patients to facilitate their adherence and reproducibility. The radiographic study was performed following specific incidences: panoramic anteroposterior (AP) radiography; cross-table profile radiograph of right and left hips; Lequesne false profile radiograph of right and left hip, following the protocol proposed by Tannast et al.<sup>16</sup> Finally, CT scan of both femurs with calculation of femoral torsion. The oriented tomographic protocol was with low radiographic exposure, previously determined at 3 defined points for image acquisition, according to protocol suggested by Murphy et al.<sup>1</sup> (Fig. 1).

After the image quality check, the main bone markings and structures were identified, as well as the joint space assessment in both the AP and Lequesne incidence to assess the possibility of osteoarthritis. All non-standard images were discarded and reordered. The angles, lines and measures included in the study were: femoral torsion angle, center-edge angle, acetabular index, femoral head extrusion index, cervic-diaphyseal angle, alpha angle, acetabular version, Mc Kibbin index and degree of osteoarthritis. In all cases a manual analysis was performed by the main author, with double checking at different times, using goniometer measured in millimeters and degrees, and a compass to demarcate the sphericity of the femoral head.

### 2.3. Femoroacetabular impingement classification

The CAM impingement was evaluated on the profile radiograph of the hips, being diagnosed when the alpha angle value was greater than 50°. Pincer impingement was given by the presence of any of the following altered angles: negative acetabular index or; acetabular center-edge angle greater than 39° or; extrusion index less than 10%. These angles were evaluated on the hip AP radiograph. Measurements were obtained independently in each hip of the 26 participants (N = 26). Thus, the criteria were applied to each individual hip (N = 52). Therefore, one patient with CAM impingement on one side and Pincer on the other was not classified as having Mixed impingement. The diagnosis of altered FT was confirmed when the angles found were less than 5° (retrotorsion) and greater than 25° (antetorsion).

**Table 1**  
Comparison between types of impingement, angles and presence of symptoms.

| N                             | Control       | Painful       | p     |
|-------------------------------|---------------|---------------|-------|
|                               | 17            | 35            |       |
| Femoral torsion [mean (sd)]   | 14.76 (8.07)  | 14.49 (9.61)  | 0.918 |
| Alfa angle CAM [mean (sd)]    | 53.25 (11.80) | 62.43 (13.55) | 0.024 |
| Acetabular index [mean (sd)]  | 0.94 (4.90)   | 1.06 (5.06)   | 0.938 |
| Center-edge angle [mean (sd)] | 32.62 (9.06)  | 33.63 (7.97)  | 0.691 |
| Extrusion index [mean (sd)]   | 16.76 (13.91) | 13.67 (10.65) | 0.385 |

n = number, sd = standard deviation, p = t-test from Student.

### 3. Statistical analyzes

All analyzes were performed using the R software version 3.4.4. The criterion of statistical significance was p-value < 0.05.

### 4. Results

After applying the inclusion and exclusion criteria, the average of age was 35 years and the mHHS were 67 points. The average BMI was 24.02 kg/m<sup>2</sup>. After performing the measurements, the hips were assessed separately for pain occurrence. On average, the alpha angle was significantly higher in painful hips than in pain-free hips (p = 0.024) (Table 1).

Relative variability of alpha angle was resumed by the coefficient of variation (CV) and evaluated by study group. There was a variation in the torsion angle, of 66.4% in the painful hips and 54.7% in the control hips. The alpha angle showed a variation around 22% in both groups. All three types of impingement appeared to occur with similar proportions (p = 0.432). We evaluated the difference between the prevalence of CAM, Pincer and Mixed impingement in each gender. The results indicated that CAM-type affected more men than women. In the sample, CAM-type was 19 times more frequent in men than in women (OR: 19.00, CI: [2.54, 141.91]). There was no evidence of differences between men and women in occurrences of Pincer type (CI: [0.26, 2.16]) and Mixed type (CI: [0.76, 6.33]). We observed that the presence of Mixed type was 7 times more frequent in the painful hips (OR: 7.00, CI: [1.59, 30.80]) than in the control group. There were no significant differences in occurrences for CAM (CI: [0.90, 6.07]) and Pincer (CI: [0.35, 2.85]) (Fig. 2).

The mean FT of the painful hips with CAM-type was not statistically significant difference when compared to the control hips (p = 0.234). In Pincer impingement, the average torsion of the painful hips was 16.63°, while the average torsion of the controls was 11.77° (p = 0.045). The average torsion of the painful hips that have a Mixed type was not different when compared to the controls (p = 0.314). In a global evaluation, the torsion angle was inversely proportional to the alpha angle (r = -0.30, p = 0.036), as shown in the regression line that associates the measurements of these angles (Fig. 3). Torsion angle was negatively correlated with alpha angle (r = -0.65, p = 0.011) in the control group, but the correlation was not significant in the painful hips group (r = -0.21, p = 0.233) (Fig. 3).

Under the hypothesis of a linear correlation between the FT angle as a function of the alpha angle, linear regression models were adjusted for each group. The negative correlation had less marked effect on the painful hip group than on the control group. Controlling for the study group, the association remains significantly negative in the control group (p = 0.012).

When the analysis by the type of impact was controlled, it was not possible to identify an association with the angle of the FT anymore. However, a similar trend of association between the groups of patients with hip pain and controls was noted, in the different types of impingement, CAM, Pincer and Mixed (Fig. 3).

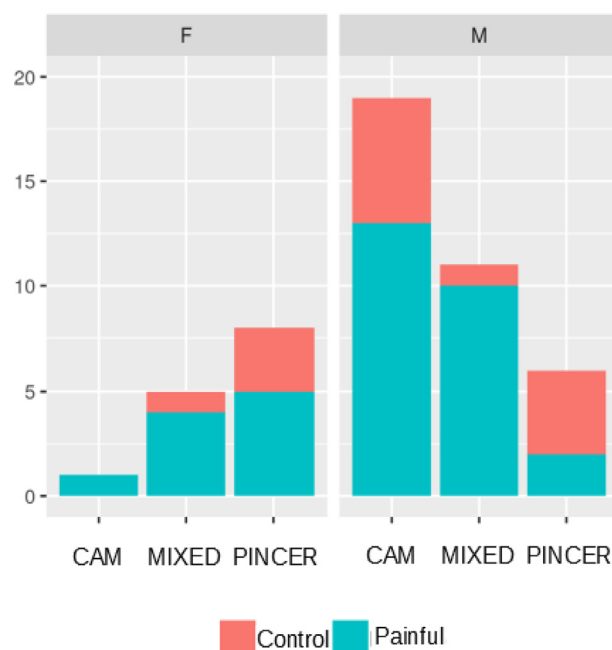


**Fig. 2.** Number of stratified hips by gender, study group, and different types of femoroacetabular impingement. Two non-painful hips had no FAI, so N = 50.

### 5. Discussion

After the publication of the results from the surgical treatment of FAI by Ganz et al., 2003, several modalities of diagnosis and treatment of this pathology have been increasing in quantity and quality.<sup>10</sup> Any imperfection between femoral head adjustment and acetabulum may lead to undesired outcome: osteoarthritis. Thus, the diagnoses of osteoarthritis, previously classified as idiopathic, were elucidated almost entirely. It was concluded that FAI corresponded for most of the mechanical alterations of this joint. In this context, the contribution of FT in this process has become object of interest as the biomechanical interpretation of every lower limb is again of major importance.<sup>12</sup> It is believed that 10% of the population has hip osteoarthritis.<sup>7</sup> Since FAI is the main cause of hip osteoarthritis, its diagnosis and treatment are critical. On the other hand, not all aspects related to FAI have been understood yet, especially when related to its signs and symptoms, as some patients may present nonspecific pain in more severe cases of osteoarthritis. Despite anatomical changes, pain may not be present initially, making important to combine signs and symptoms with radiographic findings. Thus, the study compared painful to non-painful hips, identified as control, where 88% from the painless group had some radiographic signs of impingement.

The current study found an association between femoral torsion and FAI in 11 patients with hip pain (31%). Ejnisman et al. identified an association between FT and the degree of joint damage in the FAI. They retrospectively evaluated 188 patients undergoing hip arthroscopy and observed that when the femoral torsion was greater than 15°, the hip lesions were more severe. FT in their study ranged from -10 to 27°.<sup>16</sup>

In our evaluation of the FAI, it was possible to identify that the alpha angle was higher in the painful hips, being 62.43° on average, against 53.25° on the control group (p = 0.024). However, such difference was not observed identified on the other measured angles. Fernquest et al. evaluated 40 patients with CAM impingement by dynamic computed tomography (4D CT) and observed that cases where the alpha angle was greater than 60° the impingement could already occur in flexions of 45° of the hip. They did not evaluate femoral torsional angle, which could be associated, making the range of motion deficit more severe.<sup>18</sup> In this study, the range of motion was measured in all patients. With the evolution of arthrosis, joint mobility decreases

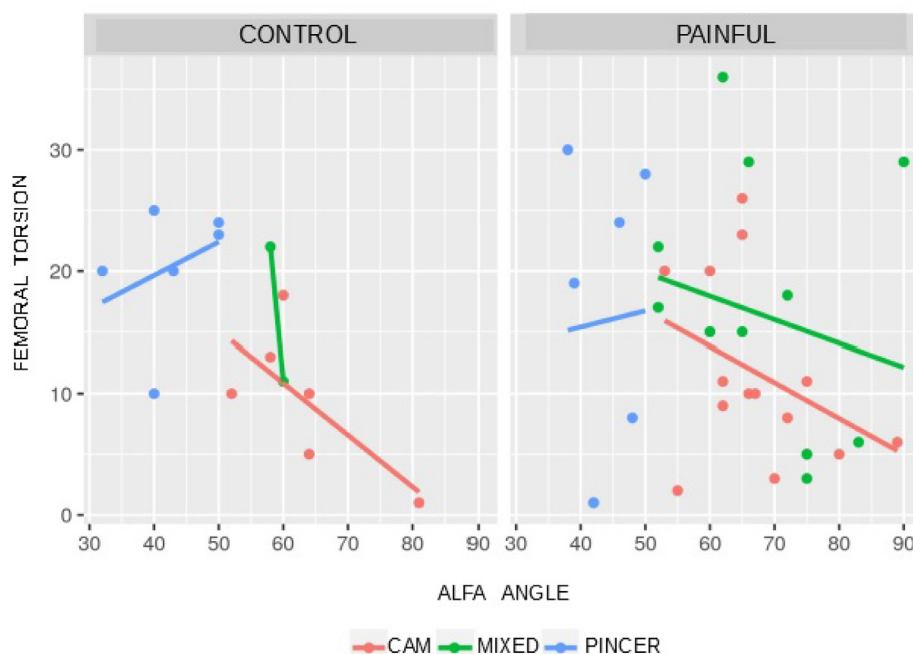


Fig. 3. Linear regressions between the FT angle and the alpha angle for each study group. Comparison between painful and control hips for each type of FAI.

progressively<sup>7,8,11</sup> and perhaps due to the low degree of osteoarthritis from the selected patients, a significant deficit of joint mobility wasn't observed.<sup>18</sup>

The average torsion angle found in the evaluated hips was 14.5° (ranging from 0 to 39°). Studies present varied results when evaluating the FT angle in different populations.<sup>8,12,17,20,21</sup> Maheshwari et al. conducted a prospective study in India by femoral neck (CT) on 86 people with no complaints of hip pain in order to obtain normal population values. The FT angle ranged from 6.5 to 10° (mean 8°), the acetabular version ranged from 16 to 22° (mean 19°) and the Mc Kibbin index ranged from 23.5 to 30° (mean 27°).<sup>19</sup> Brazil has a mixed population derived from European, African and Amerindian. Palatinik et al. evaluated the ethnic heritage of a Brazilian population based on the measurement of 8 genetic systems, concluding that we have a very particular morphogenetic characteristic, different from other populations.<sup>13</sup>

The coefficients of variation (CV) for FT and alpha angle found revealed valuable information. The CV of FT in the painful hips was 66.4%, and in the control hips was 54.7%. Regarding the alpha angle, the CV found was approximately 22% in both groups, considered low (< 25%). This high variability for FT, considering the measurement recommended by CT of high reliability and precision, translates heterogeneous results on this measurement. We could extrapolate that in the evaluation of a patient with FAI, FT changes may occur unexpectedly, and such unpredictability could result in inaccurate diagnosis and imprecise surgical planning.

In Conclusion, the presence of torsional alterations in almost 1/3 of the patients with FAI and the high variability reveal the importance of measuring FT in this pathology.

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#### Declaration of competing interest

None.

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