Original Research

Hip Rotation and Femoral Anteversion and Its Influence on Traction Force of the Pulled Limb in Hip Arthroscopy

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Background: Several variables may affect the traction force during hip arthroscopy. Specifically, the degree of hip joint rotation may influence the magnitude of traction force during hip arthroscopy. However, there is currently limited research available on this particular issue.

Purpose: To quantify the traction force applied to the pulled limb in various traction states and rotational positions. Additionally, the study aimed to investigate potential correlations between femoral anteversion, BMI, anesthesia methods, and the traction force required for hip dislocation.

Hypothesis: It was hypothesized that traction force in different traction states and rotational positions would be different and that femoral anteversion, body mass index (BMI), and anesthesia methods may influence the traction force needed.

Study Design: Cross-sectional study; Level of evidence, 4.

Methods: Patients who attended the sports medicine clinic of our department and underwent arthroscopic surgery for the diagnosis of femoroacetabular impingement between June and December 2022 were retrospectively evaluated. The traction force at the following 6 key timepoints was measured—initial traction, traction to the operable width, after joint puncture, after capsulotomy, at 20 minutes after capsulotomy, and at 40 minutes after capsulotomy. In each state, the hip was rotated to the internal rotational position, external rotational position, and neutral position. The traction force at different states and positions was recorded and analyzed. The differences in traction force between the different joint capsular physical states and rotational positions were tested by analysis of variance and the Tukey method. The Pearson test was used to analyze the correlation between BMI and femoral anteversion in different groups.

Results: A total of 41 patients were included in this study. The traction force increased after reaching the operable width and decreased significantly after capsulotomy ($P < .05$). Thereafter, the traction force decreased gradually over time ($P < .05$). Traction force in the external and internal rotational positions was significantly greater than that in the neutral position, across all states of traction ($P < .05$). Furthermore, the difference in traction force between the internal and neutral positions, as well as the difference in traction force between the external and neutral positions, was found to be significantly greater than the difference in traction force between the internal and external rotational positions in all traction states ($P < .05$). The difference between the traction forces in different rotational positions of the hip joint exhibited a negative correlation with femoral anteversion (Pearson correlation coefficient of neutral-internal in states 3, 4, and 5 was –0.33, –0.31, –0.31, respectively; $P < .05$) and a positive correlation with BMI (Pearson correlation coefficient of external-neutral in states 4 and 6 was 0.33 and 0.36, respectively; $P < .05$).

Conclusion: Our findings show that the traction force decreased after joint puncture and capsulotomy and decreased over time during surgery. External or internal rotation increased the traction force. Patients with higher femoral anteversion or lower BMI may need lower traction force. These data may help in minimizing traction forces to help prevent complications due to traction during hip arthroscopy.

Keywords: hip arthroscopy; traction; femoral anteversion; hip rotation; hip: femoroacetabular impingement

Hip arthroscopy has become increasingly common in the field of general orthopaedics, particularly among hip

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surgeons.[7] Before the surgery begins, the patient's affected limb needs to be given a certain amount of traction force to provide sufficient working space. Previous studies have shown that traction force may be associated with postoperative complications such as nerve damage and skin necrosis or tearing.[2,4,15] Therefore, appropriate evaluation of factors that influence the traction force may reduce postoperative complications and improve patient prognosis.

Several variables may affect the traction force during hip arthroscopy. A previous study suggested that male patients and individuals with higher body mass index (BMI) require greater traction force than others.[16] However, a recent study found no significant relationship between BMI and traction force.[20] Muscle volume and strength were also important indicators for assessing traction force.[11,20] In our daily work, we have observed that the rotational position of the hip joint can potentially affect the traction force. Specifically, during hip arthroscopy, the degree of the hip joint rotation may influence the magnitude of traction force. However, there is currently limited research available on this particular issue.

Therefore, the purpose of this study was to quantify the traction force applied to the pulled limb in various traction states and rotational positions. Additionally, the study aimed to investigate potential correlations between femoral anteversion, BMI, anesthesia methods, and the traction force required for hip dislocation. We hypothesized that traction force in different traction states and rotational positions would be different and that femoral anteversion, BMI, and anesthesia methods would likely influence the traction force needed.

METHODS

Patients

We retrospectively evaluated patients who attended the sports medicine clinic of our department and underwent arthroscopic surgery for the diagnosis of femoroacetabular impingement (FAI) between June and December 2022. The inclusion criteria were as follows: all patients (1) who were diagnosed with FAI and who underwent arthroscopic surgery and (2) who had traction force measured and recorded in all positions needed. The exclusion criteria were as follows: (1) previous hip surgery, (2) avascular necrosis of the femoral head, (3) Legg-Calve-Perthes disease, (4) Ehlers-Danlos syndrome, and (5) pigmented villonodular synovitis, osteoid osteoma, synovial chondromatosis, and rheumatologic disease. The ethics committee of our hospital approved the protocol for this study, and all participants provided written consent for participation.

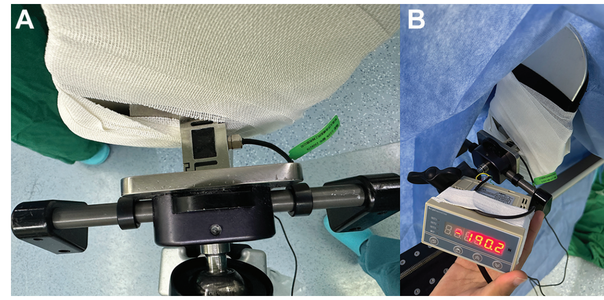

Figure 1. (A) Force-measuring device using an S-shaped force sensor connected to the boot of the hip positioning system. (B) The real-time force can be read on the screen.

Surgical Method

After general or spinal anesthesia, patients were placed on a hip traction bed in a supine position. A perineal post (diameter, 20 cm) was used to provide support. The affected limb was pulled with a hip positioning system (Smith + Nephew) before surgery. The feet were fixed in boots and given initial traction (state 1). Then, the boots were pulled to increase the hip joint space to the operable width (joint space width range, 12-20 mm) (state 2). Fluoroscopic images were taken to determine the position and width of the bony hip joint space. Measurements were performed from the lateral point (the most lateral aspect of the acetabular sourcil line) along the acetabular sourcil line, perpendicular to the surface of the femoral head.[3] The width was measured on the mobile radiographic systems (OEC One CFD; General Electric). Under fluoroscopy, the No. 22 puncture guide needle (Smith + Nephew, diameter, 1.2 mm) was inserted (state 3) and an anterolateral approach was made. Then, the midanterior portal was made and the external and anterior (12 o'clock-3 o'clock) articular capsules were cut open (state 4). Most pathology in the central compartment, including pincer deformity, labral injury, and chondrolabral injury, can be treated using this approach. After addressing the pathology of the central compartment, the arthroscope was introduced into the peripheral compartment for decompression of the cam deformity. A satisfactory cam resection was confirmed with intraoperative fluoroscopy and dynamic examination. The capsule was repaired routinely at the end of the procedure.

Traction Force and Radiographic Measurement

As shown in Figure 1, we connected the force sensor with a measuring range of 0 to 1000 N and an accuracy of 0.1

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Ethical approval for this study was obtained from Peking University Third Hospital (ref No. M2019193).

TABLE 1
Descriptive Characteristics[a]

Parameter	Value (N = 41)
Age, y, mean (range)	38.2 (18-55)
Sex	
Male	21 (51.2)
Female	20 (48.8)
BMI, kg/m^2, mean (range)	23.0 (17.3-30.2)
Alpha angle, deg	58.7 ± 6.8
LCEA, deg	34.2 ± 7.3
Femoral anteversion, deg	17.8 ± 4.2
Diagnosis	
Cam-type FAI	38 (92.7)
Pincer-type FAI	28 (68.3)
Labral tear	41 (100)

[a]Data are presented as n (%) or mean ± SD, unless indicated otherwise. BMI, body mass index; FAI, femoroacetabular impingement; LCEA, lateral center-edge angle.

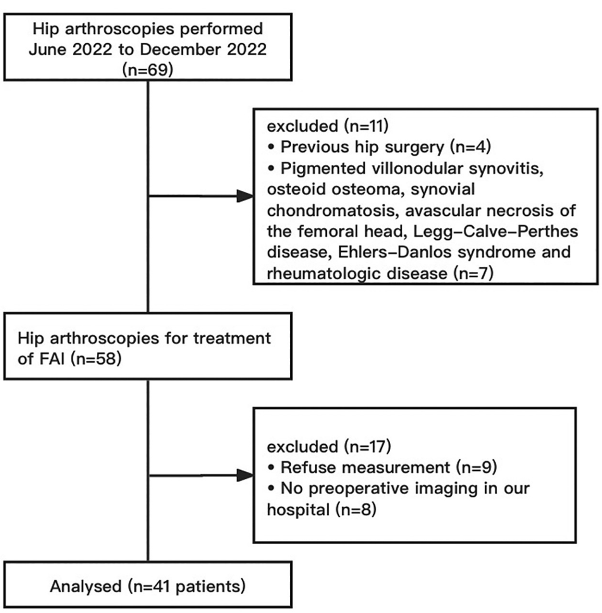

Figure 2. Flowchart illustrating the patient selection process. FAI, femoroacetabular impingement.

N (DYLY-108; YOUNG Ltd) to the boot of the hip positioning system, ensuring that the measuring direction of the sensor was aligned with the direction of the traction force.[20] This ensured that the traction force was applied to the affected limb while allowing us to perform internal or external rotation during the surgery. The sensor was connected to an electronic display, which showed the magnitude of the traction force in real time without the need for manual control.

We measured the traction force at the following 6 key timepoints: initial traction (state 1), traction to the operable width (state 2), after joint puncture (state 3), after capsulotomy (state 4), 20 minutes after capsulotomy (state 5), and 40 minutes after capsulotomy (state 6). In each state, we rotated the hip to the internal rotational position (15°), external rotational position (15°), and neutral position and measured the traction force at each rotational angle twice, taking the mean value. A goniometer was used to measure rotational degree. One of the authors, a surgeon (Y.X.) with 10 years of clinical experience, manually recorded all the measurements.

The preoperative alpha angle and lateral center-edge angle (LCEA) were measured on the 45° Dunn view and supine anteroposterior hip radiographs, respectively, as described in previous studies.[1,19] Femoral anteversion was measured by multiple computed tomographic cross sections by the Murphy method.[10,18]

Statistical Analysis

The data were analyzed and plotted using SPSS software (Version 26; IBM Corp). The differences in traction force between the different joint capsular physical states and rotational positions were tested by analysis of variance and the Tukey method. The normality of the distribution was confirmed by Shapiro-Wilk test, and the mean value of each group was calculated. After that, the Pearson test was used to analyze the correlation between BMI and femoral anteversion in different groups. A value of $P < .05$ was considered significant. G*Power 3.1 (Universität Düsseldorf) was used to estimate the sample size required for the study. Analysis of variance was conducted for the same group of samples. The expected statistical effect was set at 95%, the significance level of the test was .05, and the correlation coefficient between the measurements was 0.5.

RESULTS

A total of 41 patients (mean age, 38.2 years; 21 male and 20 female) were included in this study. A flowchart illustrating the full patient selection process can be found in Figure 2. BMI, alpha angle, LCEA, and diagnosis are given in Table 1. There were no complications or revision hip arthroscopy reported in this study.

The mean traction forces at different states and rotational positions are shown in Figures 3, 4, and 5 and Table 2. The results showed significant differences in traction force between each state ($P < .05$, specific P values are shown in Table 2). The traction force increased after reaching the operable width (state 2) and decreased significantly after capsulotomy (state 3). After that, the traction force decreased gradually over time. Moreover, the results showed significant differences in traction force between the rotational positions ($P < .05$, specific P values are shown in Table 2). Traction force in external and internal rotation was significantly greater than that in the neutral position, across all states of traction ($P < .05$, specific P values are shown in Table 2).

Table 2 and Figure 6 demonstrate differences in traction forces across different states and rotational positions. In all traction states, the difference in traction force

TABLE 2
Traction Force of the Joint Capsule[a]

State	Rotational Position	Male	Female	All Patients	N-I (All Patients)	E-N (All Patients)	E-I (All Patients)	*P* (Male and Female)	*P* (Male and All)	*P* (Female and All)	*P* (Difference Between Positions)
1	Neutral	277.3 (128.5-568)	212 (106-377.5)	245.5 (106-568)	6.5 ± 9.4	9.0 ± 11.8	–2.6 ± 13.4	.019	.21	.15	.30$^{\text{N-I and E-N}}$
	Internal	281.8 (142-576)	220.6 (108-383)	251.9 (108-576)				.029	.24	.18	.0015$^{\text{N-I and E-I}}$
	External	285.8 (119-585)	221.7 (127-399)	254.5 (119-585)				.028	.24	.17	.00020$^{\text{E-N and E-I}}$
2	Neutral	567.9 (450-759)	442.4 (331.5-572)	506.7 (331.5-759)	17.8 ± 21.7	19.6 ± 25.7	–1.8 ± 22.8	2.3 × 10E-5	.028	.015	.75$^{\text{N-I and E-N}}$
	Internal	587.2 (458-775)	458.6 (353.5-602)	524.5 (353.5-775)				1.0 × 10E-5	.021	.013	1.6 × 10E-4$^{\text{N-I and E-I}}$
	External	590.7 (469.5-771)	458.7 (339.5-587)	526.3 (339.5-771)				1.3 × 10E-5	.022	.015	3.7 × 10E-4$^{\text{E-N and E-I}}$
3	Neutral	492.9 (390.5-680)	386.3 (227-520)	439.5 (227-680)	18.3 ± 10.2	31.0 ± 16.4	–12.7 ± 19.8	1.1 × 10E-4	.035	.032	9.2 × 10E-5$^{\text{N-I and E-N}}$
	Internal	513.8 (407-717)	402.9 (250.5-551.5)	458.3 (250.5-717)				1.0 × 10E-4	.035	.031	1.9 × 10E-12$^{\text{N-I and E-I}}$
	External	527.9 (434.5-705)	415.0 (248-557.5)	471.4 (248-705)				5.7 × 10E-5	.028	.027	5.2 × 10E-17$^{\text{E-N and E-I}}$
4	Neutral	441.2 (279.5-666)	327.4 (206.5-449.5)	382.9 (206.6-666)	15.8 ± 19.8	23.1 ± 17.8	–7.4 ± 22.5	1.0 × 10E-4	.038	.027	.89$^{\text{N-I and E-N}}$
	Internal	461.4 (305-665)	339.0 (219-472.5)	398.6 (219-665)				6.2 × 10E-5	.031	.026	1.1 × 10E-5$^{\text{N-I and E-I}}$
	External	467.7 (313-665)	347.4 (228.5-458)	406.0 (228.5-665)				2.4 × 10E-5	.025	.019	6.7 × 10E-9$^{\text{E-N and E-I}}$
5	Neutral	411.6 (258-615)	308.3 (185.5-509)	358.6 (185.5-615)	19.8 ± 12.1	26.3 ± 32.6	–6.5 ± 30.5	7.9 × 10E-4	.069	.058	.25$^{\text{N-I and E-N}}$
	Internal	431.2 (282-620)	328.2 (196-529)	378.4 (196-620)				9.0 × 10E-4	.066	.061	1.0 × 10E-5$^{\text{N-I and E-I}}$
	External	436.0 (218-613)	336.3 (179-550)	384.8 (179-618)				.0019	.075	.086	2.2 × 10E-5$^{\text{E-N and E-I}}$
6	Neutral	389.5 (210.5-591)	290.7 (164.5-461)	337.4 (164.5-591)	19.1 ± 15.3	20.9 ± 13.5	–1.8 ± 19.9	.0015	.074	.077	.70$^{\text{N-I and E-N}}$
	Internal	410.6 (228-595)	308.1 (181-480)	356.5 (181-595)				.0013	.071	.074	1.0 × 10E-5$^{\text{N-I and E-I}}$
	External	411.9 (230-592)	310.3 (179-484.5)	358.3 (179-592)				.0013	.07	.075	9.3 × 10E-7$^{\text{E-N and E-I}}$

[a]Data are presented as mean ± SD or mean traction force (N) (range) . The difference of the traction force at different states and rotational positions are shown in the table. E-I, external-internal; E-N, external-neutral; N-I, neutral-internal.

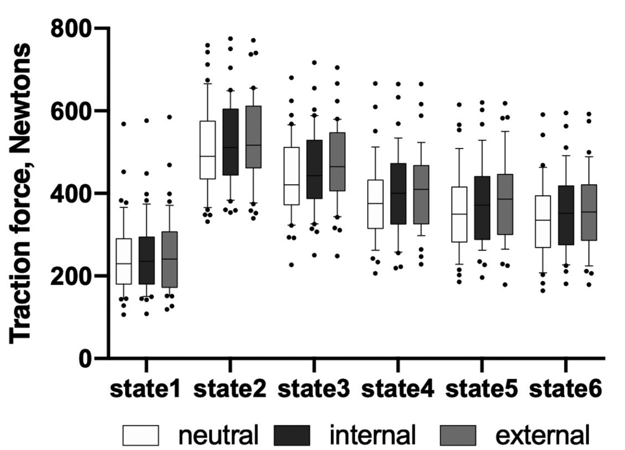

Figure 3. The mean traction force of all patients in different states and rotational positions. In the box plots of Figures 3 to 5, the boundary of the box closest to 0 indicates the 25th percentile, a black line within the box marks the median, and the boundary of the box farthest from zero indicates the 75th percentile. Whiskers above and below the box indicate the 10th and 90th percentiles. Points above and below the whiskers indicate outliers outside the 10th and 90th percentiles.

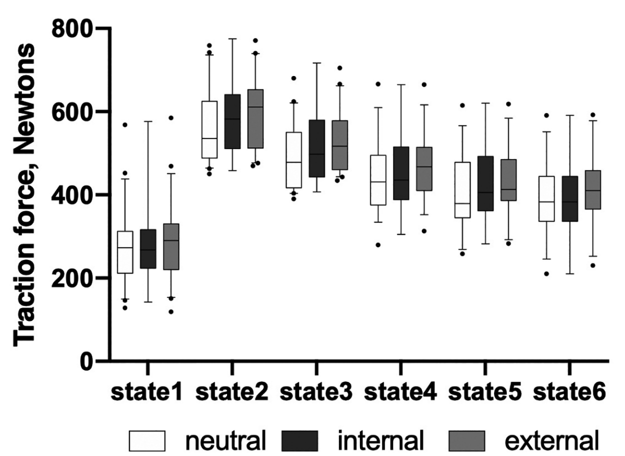

Figure 4. The mean traction force of male patients in different states and rotational positions. In the box plots, the boundary of the box closest to zero indicates the 25th percentile, a black line within the box marks the median, and the boundary of the box farthest from zero indicates the 75th percentile. Whiskers above and below the box indicate the minimum and maximum.

between the internal and neutral positions, as well as the difference in traction force between the external and neutral positions, was found to be significantly greater than the difference in traction force between the internal and external rotational positions (P < .05, specific P values are shown in Table 2). In state 3, the difference between the external rotational position and the neutral position was greater than that between the internal rotational position and the neutral position (P = 9.2 × 10E-5).

There was a significant difference in traction forces between different sexes (Table 2), while different types of anesthesia showed no significant effect on traction forces. As shown in Table 2, there was a significant difference in traction force between male and female patients in all states and positions, with male patients exhibiting noticeably higher levels of force than their female counterparts

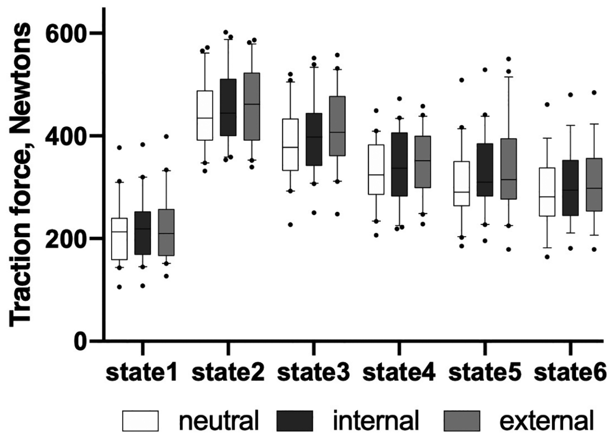

Figure 5. The mean traction force of female patients in different states and rotational positions. In the box plots, the boundary of the box closest to zero indicates the 25th percentile, a black line within the box marks the median, and the boundary of the box farthest from zero indicates the 75th percentile. Whiskers above and below the box indicate the minimum and maximum.

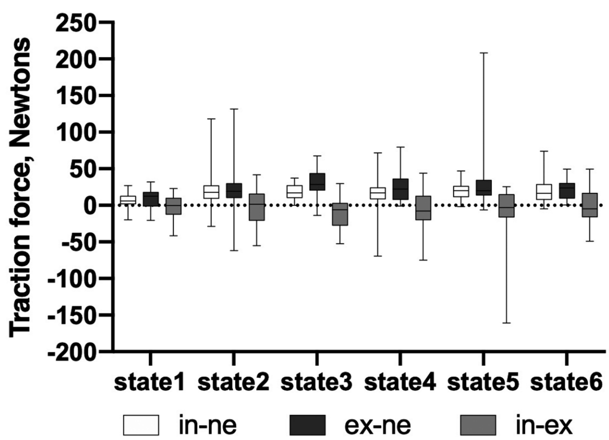

Figure 6. Traction force changes at different traction states and rotational positions in all patients. In the box plots, the boundary of the box closest to zero indicates the 25th percentile, a black line within the box marks the median, and the boundary of the box farthest from zero indicates the 75th percentile. Whiskers above and below the box indicate the minimum and maximum. ex-ne, external-neutral; in-ne, internal-neutral; in-ex, internal-external.

($P < .05$, specific P values are shown in Table 2). Neither different anesthesia methods (general vs combined anesthesia) nor the application or nonapplication of nerve block showed a significant impact on the traction force ($P > .05$).

There was a significant negative correlation between traction force and femoral anteversion in the internal and external rotational positions in state 2 (internal, P = 0.03; external, P = 0.03), as well as in the internal and external rotational and neutral positions in state 3 (neutral, P = 0.002; internal, P = 0.003; external, P = 0.002) (Table 3). The traction forces in external rotation in states 2 and 3 significantly correlated with BMI (stage 2, P = 0.02; stage 3, P = 0.02) (Table 3).

The difference in traction force between the internal rotational and neutral positions of states 3, 4, and 5 had a significant negative correlation with femoral anteversion (stage 3, P = 0.03; stage 4, P = 0.02; stage 5, P = 0.02). Higher femoral anteversion predicted a smaller difference in traction force between the internal rotational and neutral positions. The differences between the traction force of the external rotational and neutral positions in states 4 and 6 were also significantly correlated with BMI (stage 4, P = 0.03; stage 5, P = 0.03) (Table 3). On the whole, the difference between the traction forces in different rotational positions of the hip joint exhibited a negative correlation with the femoral anteversion and a positive correlation with BMI.

DISCUSSION

In this study, we evaluated the traction force applied to the pulled limb in various traction states and rotational positions and investigated the potential correlations between femoral anteversion, BMI, anesthesia methods, and the traction force required for hip dislocation. The major findings of our study were that the traction force decreased after joint puncture and capsulotomy and decreased over time during surgery ($P < .05$). External or internal rotation increased the traction force ($P < .05$). The difference between the traction forces in different rotational positions of the hip joint exhibited a negative correlation with femoral anteversion (Pearson correlation coefficient of neutral-internal in states 3 to 5 was –0.33, –0.31, and –0.31, respectively; $P < .05$) and a positive correlation with BMI (Pearson correlation coefficient of external-neutral in states 4 and 6 was 0.33 and 0.36, respectively; $P < .05$). Patients with higher femoral anteversion or lower BMI may need a lower traction force than others.

According to previous reports,[2,4,5,15] the magnitude and duration of traction force may increase the likelihood of complications, particularly the risk of nerve damage. This study measured the mean and range of required traction force for hip arthroscopy. Similar to previous research results,[5,20] there were significant differences in the magnitude of traction force required during surgery among patients of different sexes, with men requiring a much greater traction force compared with women, which may be related to the greater muscle volume in men and greater flexibility in women. The traction force measured in this study is close to the values obtained in a study conducted in China. Yin et al[20] reported a mean traction force of 531.8 N. The values of traction force measured in our study are slightly lower than those reported in other studies.[2,16] Roling et al[16] reported a mean traction force of 714 N (range, 390-1362 N), while Bailey et al[2] reported that the mean traction force was 59.5 ± 14.9 kgf. We believe that our study may represent the characteristics of East Asian individuals to a certain extent.

TABLE 3
Difference Between Traction Force in Various States and Rotational Positions[a]

State	Rotational Position	Femoral Anteversion	BMI	Rotational Position Difference	Femoral Anteversion	BMI
1	Neutral	0.05	–0.01	Internal-neutral	–0.26	–0.10
	Internal	0.02	–0.02	External-neutral	0.03	0.00
	External	0.05	–0.01	Internal-external	–0.2	0.09
2	Neutral	–0.29	–0.26	Internal-neutral	–0.11	0.05
	Internal	–0.32[b]	–0.27	External-neutral	–0.12	0.25
	External	–0.32[b]	0.32[b]	Internal-external	0.05	0.26
3	Neutral	–0.42[c]	0.28	Internal-neutral	–0.33[b]	0.20
	Internal	–0.43[c]	0.29	External-neutral	–0.20	0.27
	External	–0.42[c]	0.32[b]	Internal-external	0.00	0.12
4	Neutral	–0.15	0.19	Internal-neutral	–0.31[b]	0.09
	Internal	–0.21	0.20	External-neutral	–0.14	0.33[b]
	External	–0.18	0.25	Internal-external	–0.16	0.18
5	Neutral	–0.08	0.17	Internal-neutral	–0.31[b]	–0.22
	Internal	–0.12	0.15	External-neutral	0.03	–0.09
	External	–0.07	0.21	Internal-external	–0.16	0.02
6	Neutral	–0.07	0.21	Internal-neutral	0.25	0.00
	Internal	–0.08	0.20	External-neutral	–0.11	0.36[b]
	External	–0.06	0.25	Internal-external	–0.11	0.23

[a]Data are presented as n per the Pearson correlation coefficient. BMI, body mass index.
[b]$P < .05$.
[c]$P < .01$.

One of the most important findings was that there were significant differences in traction force at different rotational positions, with significantly higher traction forces in the internal and external rotational positions than in the neutral position. This may be related to changes in tension of the external and internal rotation muscle groups of the hip. When the hip is in external rotation, the gluteus maximus, posterior fibers of the gluteus medius, obturator internus and externus, piriformis, quadratus femoris, and superior and inferior gemellus muscles contract; while in internal rotation, the anterior fibers of the gluteus medius, gluteus minimus, and tensor fasciae latae muscles contract. The contracting muscles may increase the required traction force. However, further anatomic and biomechanical experiments are needed to confirm the specific mechanism by which rotational angle affects traction force.

The required traction force during hip arthroscopy mainly reflects the tension of the muscles and soft tissues around the hip joint. Anatomically, the hip joint capsule is mainly composed of the iliofemoral ligament, ischiofemoral ligament, and pubofemoral ligament.[6] The traction force on the leg can provoke reactive force of the capsule and the iliofemoral, pubofemoral, and ischiofemoral ligaments. In addition, the negative pressure of the joint capsule also counteracts traction force.

Many studies have explored various factors that affect the traction force. Yin et al[20] suggested that the traction force is determined by the stiffness coefficient, which was significantly correlated with the joint capsular condition, LCEA, BMI, and especially muscle volume whereas it had no significant correlation with alpha angle and Beighton score. In their research, the volume of the gluteus maximus had the strongest correlation with the stiffness coefficient and was a key predictive factor for the magnitude of traction force. Moreover, the relationship between muscle volume and stiffness coefficient is stronger in women. Roling et al[16] suggested that the elimination of the vacuum in the joint capsule would greatly reduce the traction force; however, the traction force had no significant correlation with traction force width, BMI, and the level of joint surface degeneration. Theoretically, degenerative changes leading to joint stiffness may increase the required traction force during hip arthroscopy, but this is still controversial.

The traction force required for hip arthroscopy is mainly to overcome the negative pressure inside the hip joint capsule.[13] Therefore, by puncturing the joint capsule and eliminating the vacuum, the required traction force can be effectively reduced. In this study, after puncturing the joint capsule and eliminating negative pressure, the traction force decreased significantly by about 60 N in all patients, while in men, it reached 70 N, which is similar to the results of other studies.[5,8,20] Roling et al[16] and O'Neill et al[13,14] proposed a method of joint puncture or increase of the incision area before applying traction force to reduce the magnitude of the required traction force, which can help reduce the traction force. However, whether this method is applicable to all patients needs to be determined through further experiments and discussions.

It should be noted that there was a negative correlation between the femoral anteversion and the required traction force before capsulotomy. The femoral anteversion refers to the angle between the femoral neck axis and the distal femoral condyles. An abnormal increase in the femoral anteversion may cause hip joint instability, thereby reducing traction force. Patients with higher femoral anteversion may experience increased tension in the hip joint capsule during internal and external rotation, leading to higher traction force. However, after undergoing capsulotomy, the tension in the hip joint capsule is relieved, and femoral anteversion no longer affects the traction force. Further research is needed to investigate the mechanism by which femoral anteversion affects traction force.

We also found a significant correlation between BMI and traction force at specific time periods and rotational angles, which is similar to the study by Ellenrieder et al.[5] However, this differs from some other previous research results,[16] and further research is needed to explore the correlation between BMI and traction force. In addition, we compared the required traction force of patients under different anesthesia and blockade methods but did not find a significant association.

The results of this study will help surgeons evaluate the magnitude of traction force required for hip arthroscopy in different patients, improving the accuracy and safety of the surgery. Recently, some researchers have proposed that the use of a nonperineal column support method can reduce the required traction force during hip arthroscopy and reduce the incidence of complications.[9,12,17] In the future, the differences between the 2 traction methods and the factors affecting traction force need to be studied.

This study has some limitations. First, the sample size in this study is relatively small, and since the samples are all from our hospital, there may be a certain degree of selection bias. Second, rotational positioning has limited precision, as the knee joint allows for some rotation. In this study, a goniometer was used to measure rotational degree in the boot of the hip positioning system. However, the best way to measure rotation is using intraoperative fluoroscopy to measure femoral rotation. More accurate methods for measuring hip rotation can be used in future research. Last, the retrospective nature of this study may have inherent design flaws that can affect the conclusions.

CONCLUSION

Our findings show that the traction force decreased (1) after joint puncture and capsulotomy and (2) over time during surgery. External or internal rotation increased the traction force. Patients with higher femoral anteversion or lower BMI may need lower traction force than others. These data may help in minimizing traction forces to help prevent complications due to traction during hip arthroscopy.

REFERENCES

1. Anderson LA, Gililland J, Pelt C, Linford S, Stoddard GJ, Peters CL. Center edge angle measurement for hip preservation surgery: technique and caveats. *Orthopedics*. 2011;34(2):86.
2. Bailey TL, Stephens AR, Adeyemi TF, et al. Traction time, force and postoperative nerve block significantly influence the development and duration of neuropathy following hip arthroscopy. *Arthroscopy*. 2019;35(10):2825-2831.
3. Bessa FS, Williams BT, Polce EM, et al. No differences in hip joint space measurements between weightbearing or supine anteroposterior pelvic radiographs. *Arthroscopy*. 2020;36(11):2843-2848.
4. Carreira D, Kruchten M, Emmons B, Startzman A, Martin R. A characterization of sensory and motor neural dysfunction in patients undergoing hip arthroscopic surgery: traction- and portal placement-related nerve injuries. *Orthop J Sports Med*. 2018;6(9): 2325967118797306.
5. Ellenrieder M, Tischer T, Bader R, Kreuz PC, Mittelmeier W. Patient-specific factors influencing the traction forces in hip arthroscopy. *Arch Orthop Trauma Surg*. 2017;137(1):81-87.
6. Gao G, Jiao C, Liu J, et al. Healing of joint capsule after hip arthroscopy using interportal capsulotomy and capsular closure influences clinical outcomes. *J Orthop Surg Res*. 2022;17(1):316.
7. Jamil M, Dandachli W, Noordin S, Witt J. Hip arthroscopy: indications, outcomes and complications. *Int J Surg*. 2018;54(pt B):341-344.
8. Kapron AL, Karns MR, Aoki SK, et al. Patient-specific parameters associated with traction in primary and revision hip arthroscopic surgery. *Orthop J Sports Med*. 2018;6(11):2325967118807707.
9. Mei-Dan O, Kraeutler MJ, Garabekyan T, Goodrich JA, Young DA. Hip distraction without a perineal post: a prospective study of 1000 hip arthroscopy cases. *Am J Sports Med*. 2018;46(3):632-641.
10. Murphy SB, Simon SR, Kijewski PK, et al. Femoral anteversion. *J Bone Joint Surg Am*. 1987;69(8):1169-1176.
11. O'Brien T, Reeves N, Baltzopoulos V, Jones D, Maganaris C. Strong relationships exist between muscle volume, joint power and whole-body external mechanical power in adults and children. *Exp Physiol*. 2009;94(6):731-738.
12. O'Neill D, Featherall J, Dowdle S, et al. Postless hip distraction systems decrease the amount of traction force needed to obtain adequate hip distraction versus a conventional post hip distractor. *Arthroscopy*. 2023;39(3):740-747.
13. O'Neill DC, Hadley ML, Adeyemi TF, Aoki SK, Maak TG. The effects of venting and capsulotomy on traction force and hip distraction in hip arthroscopy. *J Hip Preserv Surg*. 2020;7(3):487-495.
14. O'Neill DC, Mortensen AJ, Tomasevich KM, et al. Joint venting prior to hip distraction minimizes traction forces during hip arthroscopy. *Arthroscopy*. 2021;37(7):2164-2170.
15. Patel N, Krumme J, Golladay G. Incidence, injury mechanisms, and recovery of iatrogenic nerve injuries during hip and knee arthroplasty. *J Am Acad Orthop Surg*. 2021;29(19):e940-e949.
16. Roling MA, Mathijssen NM, Blom I, Lagrand T, Minderman D, Bloem RM. Traction force for peroperative [*sic*] hip dislocation in hip arthroscopy. *Hip Int*. 2020;30(3):333-338.
17. Salas AP, Mendez-Perez E, Mazek J, Velasco-Vazquez H, Castillo-Trevizo A. The yoga mat technique in postless hip arthroscopy. *Arthrosc Tech*. 2021;10(6):e1525-e1530.
18. Schmaranzer F, Lerch TD, Siebenrock KA, Tannast M, Steppacher SD. Differences in femoral torsion among various measurement methods increase in hips with excessive femoral torsion. *Clin Orthop Relat Res*. 2019;477(5):1073-1083.
19. Ucpunar H, Mert M, Camurcu Y, Buyuk AF, Cobden A, Sofu H. Validity of the alpha angle measurements on plain radiographs in the evaluation of cam-type femoroacetabular impingement in patients with slipped capital femoral epiphysis. *Skeletal Radiol*. 2019;48(11): 1787-1794.
20. Yin Y, Xue S, Zhang X, et al. The traction force of the pulled limb in hip arthroscopic surgery is determined by stiffness coefficient which is significantly related to muscle volume. *Knee Surg Sports Traumatol Arthrosc*. 2023;31(7):2708-2715.