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ORIGINAL ARTICLE

Incidence of tensor fascia lata muscle atrophy after using the modified Watson-Jones anterolateral approach in total hip arthroplasty

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Abstract

Background Post-operative tensor fascia lata (TFL) muscle atrophy due to superior gluteal nerve (SGN) injury during total hip arthroplasty (THA) can affect patients' post-operative hip function. This study aimed to determine the incidence of TFL muscle atrophy in THA performed via the modified Watson-Jones anterolateral approach and the risk factors for TFL atrophy.

Methods We reviewed pre- and post-operative magnetic resonance imaging (MRI) data of 164 patients who underwent cementless THA via the modified Watson-Jones approach at one institution. TFL atrophy was defined as worsening of ≥ 2 grades in the Goutallier classification or $>40\%$ decrease in the cross-sectional area (CSA) of the TFL on post-operative MRI compared to that on preoperative MRI. Patients' backgrounds were compared between those with or without TFL atrophy to determine the risk factors of TFL atrophy. Fatty atrophy grade and CSA of the gluteus minimus and medius were also evaluated.

Results Thirteen (8.0%) cases of TFL atrophy were detected. The mean body mass index (BMI) in the cases with TFL atrophy was significantly higher than in those without TFL atrophy ($p = 0.012$). The fatty atrophy grade was worse post-operatively than preoperatively; moreover, the CSA of the gluteus minimus decreased.

Conclusions We found a low incidence of TFL atrophy due to SGN injury after THA using the modified Watson-Jones approach. High BMI can be a risk factor for nerve injury. The gluteus minimus can be injured directly during surgery. We suggest that overexposure of the surgical site should be avoided, especially in patients with high BMI.

Keywords Tensor fascia lata · Total hip arthroplasty · Atrophy · Magnetic resonance imaging

Abbreviations

THA	Total hip arthroplasty
TFL	Tensor fascia lata
SGN	Superior gluteal nerve
MRI	Magnetic resonance imaging
CSA	Cross-sectional area
BMI	Body mass index

Introduction

The modified Watson-Jones anterolateral approach has become one of the most popular minimally invasive surgeries for total hip arthroplasty (THA) [1–4]. Bertin and Röttinger described this approach as a modification of the classic Watson-Jones approach, which utilizes the interval between the gluteus medius and tensor fascia lata (TFL) muscles without incising or detaching the muscles and tendons [2, 3]. Although excellent clinical results have been reported, this approach has a potential risk for injury to the intermuscular branch of the superior gluteal nerve (SGN) secondary to the retraction required for joint exposure. SGN injury can cause TFL atrophy related to post-operative hip pain, poor hip function, and the decrease in abductor muscle strength [5, 6]. Thus, TFL atrophy can influence post-operative clinical results after THA via modified Watson-Jones approach.

Muscle atrophy and damage have been assessed using muscle function tests (e.g. gait analysis and electromyography), which only provide indirect and nonspecific conclusions about specific muscle damage, or through cadaver investigation, which does not reflect the muscle damage due to nerve injury or the regenerative capacity of the muscles [7, 8]. Recently, muscle atrophy and damage after THA have

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successfully been assessed via magnetic resonance imaging (MRI) [7, 9, 10]. Additionally, fatty atrophy and changes in the cross-sectional area (CSA) of the muscle on MRI have been used to evaluate muscle damage and atrophy due to denervation [5, 6, 9, 11].

A few reports have demonstrated that TFL atrophy due to SGN injury can be found on MRI after THA using the modified anterolateral approach [5, 7]. Unis et al. reported that fatty atrophy was found in 42% of 26 subjects after THA using the modified anterolateral approach. However, their study population lacked statistical power and they performed only post-operative MRI; therefore, fatty atrophy was diagnosed without preoperative MRI, and the authors may have overestimated the rate of TFL atrophy [5]. We hypothesized that TFL atrophy after THA using the modified anterolateral approach would be found less likely in our study than in the previous study when we evaluated the atrophy using pre- and post-operative MRI. Moreover, risk factors for TFL atrophy via the anterolateral approach have never been reported. Therefore, the purposes of this study were to (1) clarify the incidence of TFL atrophy after THA using the modified anterolateral approach with pre- and post-operative MRI, (2) evaluate the risk factors for post-operative TFL atrophy, and (3) evaluate the change of other abductor muscles on MRI.

Material and methods

Patients

This study was performed in a single university hospital according to the principles of the Declaration of Helsinki. The study protocol was approved by the institutional research ethics committee. Informed consent was obtained from all patients before surgeries. We reviewed data of 240 consecutive, primary cementless THAs performed with ceramic on cross-linked polyethylene via the modified Watson-Jones approach between September 2017 and December 2018. We planned to routinely perform pre- and post-operative MRI on all patients who underwent primary THA, regardless of specific clinical signs and symptoms.

Surgical procedure

THAs were performed under spinal anaesthesia with intravenous sedation. All surgeries were performed via the minimally invasive anterolateral approach modifying the Watson-Jones approach with the patient in the supine or lateral position on a standard operating table [3, 12, 13] (Fig. 1). We performed the anterolateral approach in either the supine or lateral position, and there was no specific reason for choosing one position over the other during the study period. This approach is also called the Röttinger approach when performed in a lateral position, and it is performed by separating the intermuscular plane between the TFL and gluteus medius muscles. Each of the three independent surgeons who performed these surgeries had experience using this anterolateral approach in more than 100 cases prior to the study period. The initial incision was made on the anterolateral aspect of the hip (10–12 cm), and the interval between the TFL and gluteus medius was bluntly developed without muscle cutting or detachment. The exposed plane was not developed too proximally to minimize the risk of SGN injury because it has been reported that the branch of SGN runs into the TFL 3–5 cm proximal to the tip of the greater trochanter [1, 6, 9]. After capsulotomy, all patients underwent cementless implantation with ceramic-on-highly cross-linked polyethylene bearings using short taper-wedge type stems. In 85 cases, Accolade II (Stryker Orthopaedics, Mahwah, NJ, USA) was used in combination with Trident PSL cups (Stryker Orthopaedics). In 62 cases, Taperloc Microplasty (Zimmer Biomet, Warsaw, IN, USA) was used in combination with G7 acetabular cups (Zimmer Biomet). In 15 cases, Actis (Depuy Synthes, Warsaw, IN) was used

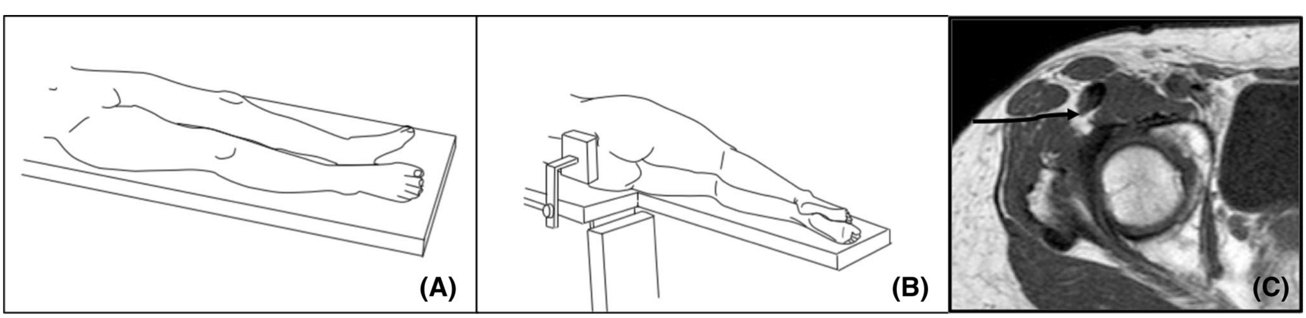

Fig. 1 The anterolateral approach is performed in either the supine or lateral position **(a, b)**. In the lateral position, the patient is positioned on the operating table with the affected side up. The posterior half of the operating table distal to the pelvis is removed before surgery to enable the femur to be positioned with extension, external rotation, and adduction during femoral preparation **(b)**. This approach is performed by separating the intermuscular plane between the tensor fascia lata and gluteus medius muscles **(c)**. To minimize the risk of superior gluteal nerve injury, it is ensured that the exposed plane is not too proximal

in combination with Trident PSL cups, and in two cases, Initia (Kyosera, Kyoto, Japan) was used in combination with Trident PSL cups. Intraoperative radiographs, fluoroscopy, and other computer-assisted devices were not used. Patients were mobilized on the first post-operative day with full weight bearing, and rehabilitation was started. They were discharged when they could walk with a cane for 200 m.

Data collection and assessment

Patient background data (age, sex, side of surgery, height, body weight, body mass index [BMI], and diagnosis), Crowe type [1, 14], preoperative and the most recent post-operative Japanese Orthopaedic Association score (0–100, worst to best) [6], surgical data (operating time, intraoperative blood loss), and early complications at the latest follow-up (e.g. dislocation, infection, intraoperative fracture) were reviewed.

Muscular atrophy and fatty infiltration were evaluated using pre- and post-operative MRI. Muscle atrophy with fatty infiltration due to denervation develops within months after nerve injury [15]. Therefore, MRI was performed later than 6 months after the time of operation. All magnetic resonance images were obtained using a 1.5-T scanner (Signa HDxt 1.5 T; GE Healthcare, Waukesha, WI, USA) in the axial, coronal, and sagittal planes to include the lower pelvis and both hips. The imaging parameters were as follows: field of view = 240 mm, repetition time/echo time = 443/12 ms, slice interval = 1.5 mm (after zero-fill interpolation), matrix size = 512 × 256, and acquisition time = 5 min 30 s. Fatty atrophy of the TFL was assessed using a transverse T1-weighted MRI and the Goutallier classification (grade 0 = no fat; 1 = few fatty streaks; 2 ≤ 50% fat; 3 = 50%; 4 ≥ 50%) [16]. The post- and preoperative cross-sectional areas of the TFL muscle were determined using ImageJ (National Institute of Mental Health, Bethesda, Maryland, USA). Both fatty atrophy and changes in CSA of the TFL were evaluated at the level of the lesser trochanter. The fatty atrophy grade and the changes in CSA were also evaluated in the gluteus medius and minimus at the level of anterior superior iliac spine. The CSA and fatty atrophy grade on MRI were evaluated by one surgeon (RT). To clarify intra- and inter-observer reliabilities, a second assessment was performed 4 weeks later by the same surgeon (RT), and another surgeon (MH) performed the same assessment in 30 cases. Before these evaluations, the two observers engaged in discussion to make a consensus about the fatty grade and procedure of measuring CSAs. For these analyses, intraclass correlation coefficients and Kappa coefficients were used. The findings showed good reliability for both intra- and inter-observer reliabilities (from 0.75 to 0.98).

TFL atrophy was defined as a worsening of 2 or more grades in the Goutallier classification or a ≥ 40% decrease in the CSA on the post-operative MRI [5, 7, 11]. To clarify the effect of patients' position during surgery, we compared the incidence of TFL atrophy between the supine and lateral groups. The incidence of TFL atrophy by each three surgeon was also evaluated.

Statistical analyses

Statistical analysis was performed using JMP software version 13.0.0 for Mac (SAS Institute, Cary, NC, USA). Comparisons of the fatty atrophy grade and the CSA in each muscle were performed using a paired *t* test. Other comparisons were performed using the Chi-squared test for categorical variables and the paired *t* test for continuous variables. All tests were two-sided, and $p < 0.05$ was considered statistically significant. The sample size calculation we conducted showed 154 cases would be needed to detect 20% difference in the rate of TFL atrophy between the rate in this study and that reported by Unis et al. [5] with a power of 80% at a type I error rate of 5% (G*Power 3; Düsseldorf University, Düsseldorf, Germany).

Results

Of 240 cases, 164 cases (68.3%) underwent both pre- and post-operative MRI. Only the results of these 164 cases were used for our analysis. Post-operative MRIs were performed at a mean of 6.5 months post-operatively (6.0–11.0). Patients' background and surgical data in both the TFL atrophy and no TFL atrophy groups are shown in Table 1. Thirteen cases were assessed as TFL atrophy (8.0%), of which 11 were assessed as TFL atrophy because of the change in fatty atrophy grade (Figs. 2a, b, and 3). Three cases of post-operative fatty atrophy worsened by 3 grades; the remaining eight cases worsened by 2 grades. Four cases were assessed as TFL atrophy because of the decrease in post-operative CSA (40.3–51.9% decrease; Fig. 4). Two cases were assessed as TFL atrophy because of both the change in fatty atrophy grade and the decrease in CSA. No early complications were observed in any of the cases. The mean BMI was significantly higher in the TFL atrophy group than in the no atrophy group ($p = 0.012$). There was no significant difference between the supine and lateral groups in terms of the incidence of TFL atrophy (Table 2). There was no significant difference between the three surgeons in the incidence of TFL atrophy (Table 3).

The mean fatty atrophy grades and CSAs for each muscle are shown in Table 4. Although there was no significant difference in the pre- and post-operative TFL fatty atrophy grades at the level of lesser trochanter ($p = 0.58$), the mean pre- and post-operative fatty atrophy grades of the gluteus medius and minimus were significantly different at the level

Table 1 Patients' background characteristics and pre- and post-operative JOA scores

	TFL atrophy	No TFL atrophy	*P* value
Number	13	151	N/A
Age (years)	65.1 ± 11.1 (39–81)	64.3 ± 12.4 (21–89)	0.82
Sex (Female/Male)	10/3	125/26	0.75
Diagnosis (Osteoarthritis/Osteonecrosis/Other)	9/3/1	116/23/12	0.77
Crowe type (I/II/III/IV)	13/0/0/0	115/32/4/0	0.033
Height (cm)	154.0 ± 9.4 (139–178)	155.8 ± 9.4 (132–185)	0.50
Body weight (kg)	65.4 ± 16.5 (47–105)	57.1 ± 11.7 (32–117)	0.098
Body mass index (kg/m^2)	27.3 ± 4.7 (21.3–33.2)	23.5 ± 4.0 (16.3–45.0)	0.012
Operative time (min)	98.5 ± 34.7 (66–177)	86.7 ± 22.4 (46–157)	0.25
Intraoperative blood loss (mL)	244.2 ± 122.9 (72–540)	248.7 ± 177.3 (58–1243)	0.90
Preoperative JOA score			
Pain (0–40)	11.5 ± 6.9 (0–20)	13.3 ± 7.9 (0–35)	0.43
Total (0–100)	46.0 ± 16.8 (19–77)	51.4 ± 14.3 (9–79)	0.28
Post-operative JOA score			
Pain (0–40)	36.9 ± 3.8 (30–40)	37.5 ± 3.4 (20–40)	0.63
Total (0–100)	87.8 ± 6.8 (76–97)	90.3 ± 8.9 (56–100)	0.23

TFL tensor fascia lata, *JOA* Japanese Orthopaedic Association, *N/A* not applicable

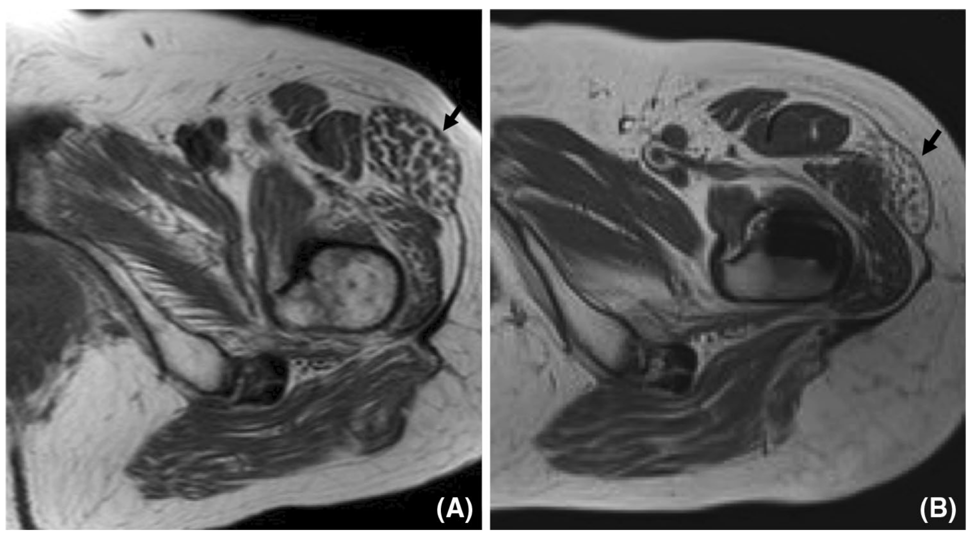

Fig. 2 Pre- **(a)** and post-operative **(b)** T1-weighted axial images: lesser trochanter (left hip) of a 68-year-old woman showing severe post-operative fatty atrophy in TFL. Fatty grade of the tensor fascia lata (TFL): grade 2 (preoperative), grade 4 (post-operative). The post-operative cross-sectional area of the TFL decreased by 48.1%

of the anterior superior iliac spines. The mean CSAs of the TFL and gluteus medius significantly increased ($p = 0.012$, $p < 0.001$, respectively). The mean CSA of the gluteus minimus significantly decreased ($p < 0.0001$) (Table 4, Fig. 5a, b).

Discussion

Our study showed the incidence of TFL atrophy (8.0%) after THA using the modified Watson-Jones approach. The pre- and post-operative mean fatty atrophy grades of the TFL were not significantly different and the mean CSA of the TFL significantly increased post-operatively. To our knowledge, ours is the first study to clarify the incidence of TFL atrophy in THA via the modified Watson-Jones approach. Moreover, our results indicated that high BMI may be a plausible risk factor for TFL atrophy.

Our incidence of TFL atrophy was lower than that in the study by Unis et al. [5]. They reported that TFL atrophy was found in 61% of 26 patients who underwent THA via the modified Watson-Jones approach. However, they assessed TFL atrophy using only post-operative MRI, which is inadequate due to the existence of preoperative abductor muscle atrophy. It was expected that the overestimation of TFL atrophy occurred in their study. The results of the

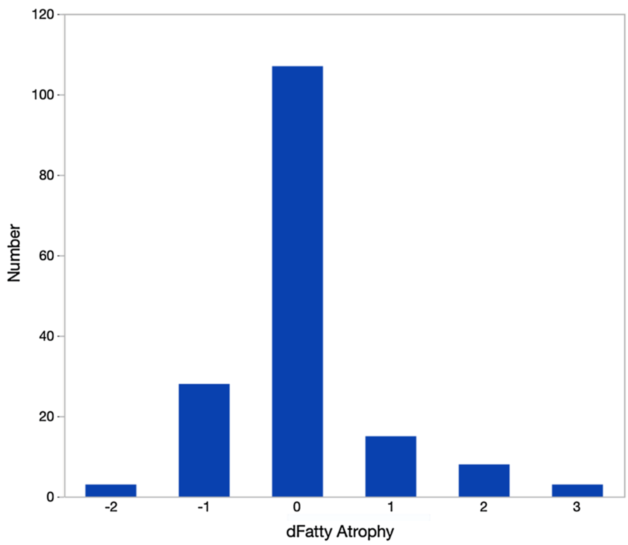

Fig. 3 Graph showing distribution of the change in grade of fatty atrophy (dFatty Atrophy) in the tensor fascia lata (TFL). Negative value indicates fatty atrophy grade of the TFL improved post-operatively. Fatty atrophy grade of the TFL remains unchanged or improves post-operatively in 83.5% of cases

randomized controlled study by Müller et al., comparing the abductor muscle atrophy of 44 patients after THA using either the modified Watson-Jones approach or a direct lateral approach, were consistent with our study [7]. They assessed muscle atrophy of the TFL and gluteus medius using pre- and post-operative MRIs. Although they did not demonstrate the incidence of TFL atrophy in modified Watson-Jones approach, they found no significant difference in the pre- and post-operative CSA and fatty atrophy grade of TFL following THA using this approach. It has been reported that the SGN runs into the TFL 3–5 cm proximal to the tip of the greater trochanter [1, 6, 9]. Avoiding exposure of the proximal part to the greater trochanter as much as possible is an important factor in preventing SGN injury. From our results, TFL atrophy due to SGN injury during THA using the modified Watson-Jones approach can be prevented in many cases.

Our results indicated that high BMI can be a risk factor for TFL atrophy. Although high BMI can be a risk factor for various post-operative complications [17, 18], it has never been identified as a risk factor for TFL atrophy. The modified Watson-Jones approach, as well as other minimally invasive approaches, provides less overview of the surgery and this disadvantage is more prominent in higher BMI cases [1, 11, 19]. Some anatomical reports have suggested that joint overexposure should be avoided in this approach to prevent SGN injury [1, 8, 20]. Thus, we consider that overexposure of the joint, which can cause SGN injury, might have been performed in the high BMI cases of our study. We recommend avoiding overexposure of the joint, especially in cases with high BMI. In this study, although we had expected that

Fig. 4 Graph showing the distribution of the rate of change of the cross-sectional area (CSA) in the tensor fascia lata (TFL). Positive value means that the CSA of the TFL increased post-operatively

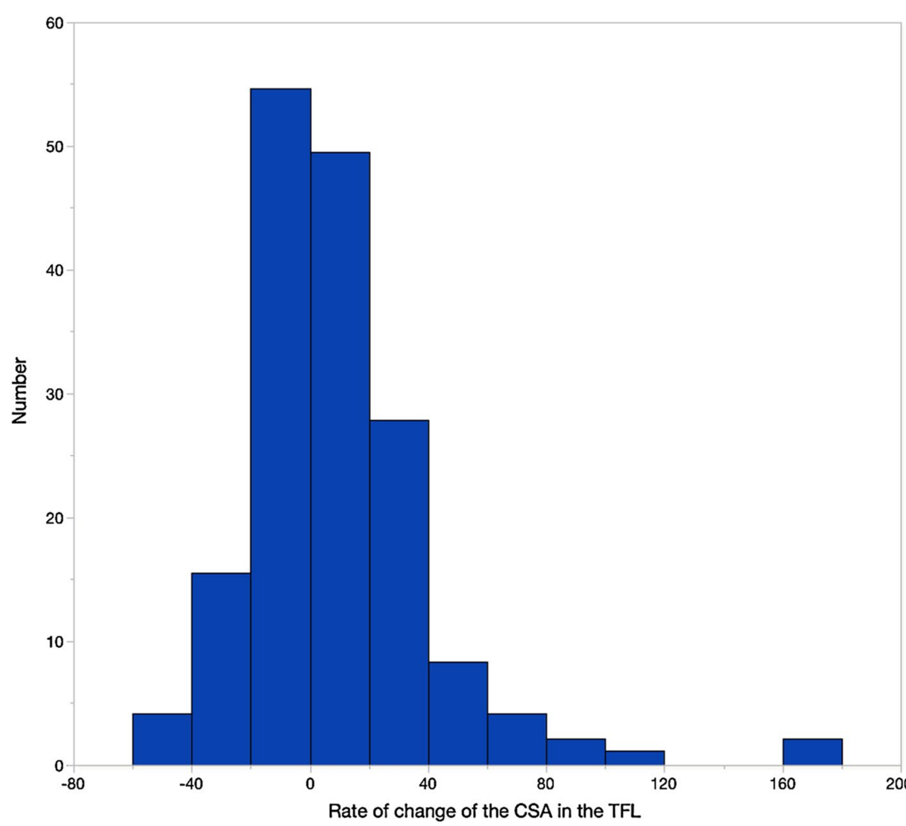

Table 2 Patients' background characteristics, surgical data, and TFL atrophy in the supine and lateral groups

	Supine	Lateral	*P* value
Number	128	36	N/A
Age (years)	65.1 ± 12.3 (21–85)	61.8 ± 12.3 (27–89)	0.15
Sex (Female/Male)	102/26	31/5	0.37
Diagnosis (Osteoarthritis/Osteonecrosis/Other)	98/21/9	27/5/4	0.72
Crowe type (I/II/III/IV)	100/26/2/0	28/6/2/0	0.43
Height (cm)	155.3 ± 8.6 (132–185)	156.9 ± 7.5 (145–178)	0.32
Body weight (kg)	56.9 ± 10.9 (32–97.9)	60.7 ± 16.2 (42–117)	0.11
Body mass index (kg/m^2)	23.5 ± 3.6 (16.3–34.5)	24.6 ± 5.6 (17.0–45.0)	0.19
Operative time (min)	83.7 ± 20.7 (46–160)	101.9 ± 28.3 (68–177)	< 0.001
Intraoperative blood loss (mL)	241.3 ± 163.2 (68–1243)	273.1 ± 205.5 (58–843)	0.33
TFL atrophy	9/128	4/36	0.44

TFL tensor fascia lata, *BMI* body mass index, *N/A* not applicable

Table 3 Incidence of TFL atrophy (Data stratified based on the attending surgeon)

	RT	KM	MH	*P* value
				0.90
Number of surgeries	41	69	54	
Number of cases of TFL atrophy	4	5	4	

TFL tensor fascia lata

TFL atrophy would be more likely in severe dysplastic cases than in non-severe dysplastic cases, we found TFL atrophy only in cases with Crowe I dysplasia. However, our study included only four cases with Crowe III dysplasia. Therefore, we cannot definitively conclude that TFL atrophy does not occur excessively in cases of severe dysplasia. More cases of severe dysplasia should be studied to clarify this.

Although the CSA in the TFL and gluteus medius significantly increased post-operatively, the CSA of the gluteus minimus significantly decreased post-operatively. The post-operative fatty atrophy grade in the gluteus minimus was also significantly worse. We expect that these results were due to direct muscle injury during surgery. Some authors reported that the muscles at the posterior part of the exposure plane were likely to be injured in an anterior or anterolateral approach (i.e. the TFL for the direct anterior approach and the gluteus minimus and medius for the anterolateral approach) [6, 11, 21]. In fact, we occasionally found direct gluteus minimus or medius injury, especially during femoral preparation in some cases [6]. Care should be taken to avoid direct gluteus minimus injury using this approach.

There are several limitations to our study. First, although we found significant differences among muscle CSA change, we did not evaluate the whole volume of muscles. A three-dimensional muscle evaluation might be more effective to find differences. Second, all surgeries were performed by independent experienced surgeons. Incidence of TFL atrophy might increase if surgeries were performed by less experienced surgeons. Third, although the previous studies revealed a certain relationship between SGN injury and post-operative atrophy, there was a possibility that the TFL atrophy we found in this study occurred not due to SGN injury but due to direct muscle injury during surgery. Combination

Table 4 Fatty atrophy grade and CSA of each muscle

	Preoperatively	Post-operatively	*P* value
TFL			
Fatty atrophy	1.1 ± 0.6 (0–3)	1.1 ± 1.0 (0–4)	0.58
CSA (mm^2)	532.0 ± 183.7 (160–1042)	562.2 ± 198.6 (193–1100)	0.012
Gluteus medius			
Fatty atrophy	0.9 ± 0.8 (0–3)	0.6 ± 0.7 (0–3)	< 0.0001
CSA (mm^2)	2438 ± 491.3 (1344–3696)	2616.9 ± 609.7 (1370–4911)	< 0.0001
Gluteus minimus			
Fatty atrophy	1.0 ± 0.8 (0–4)	1.3 ± 1.0 (0–4)	< 0.0001
CSA (mm^2)	880.5 ± 309.9 (326–2472)	787.4 ± 294.8 (232–2350)	< 0.0001

TFL tensor fascia lata, *CSA* cross-sectional area

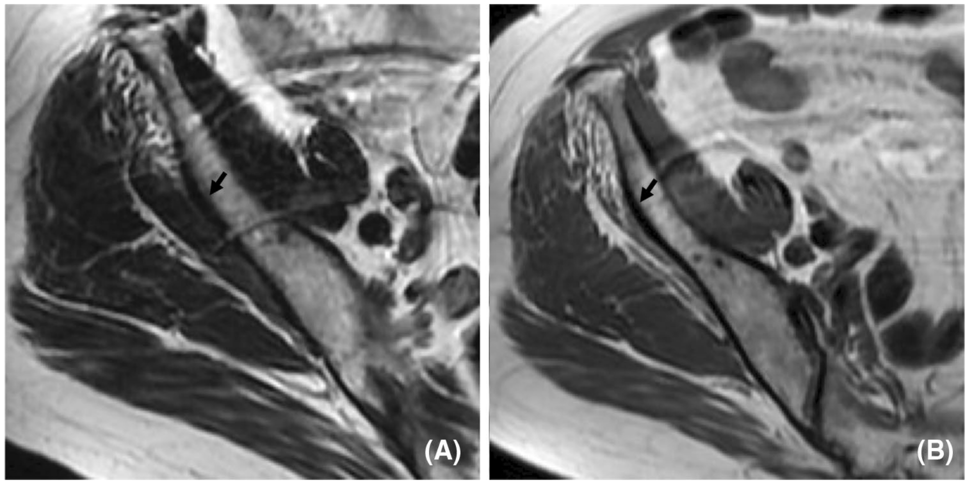

Fig. 5 Pre- (**a**) and post-operative (**b**) T1-weighted axial images: level of anterior superior iliac spines (right hip) of a 67-year-old woman showing a sharp post-operative decrease in the cross-sectional area (CSA) in the gluteus minimus. The CSA of the gluteus minimus is decreased by 62.2%

of MRI and electromyography test may be effective to solve this issue. Further studies that directly investigate the SGN injury during surgery should be conducted in the future. Fourth, we did not include a control group in this study. It is unclear whether the rate of TFL atrophy we found is lower or higher than that in the cases that underwent other approaches. Further studies that compare the TFL atrophy rate between other approaches should be conducted in the future. Fifth, as this study was conducted in an Asian country, osteoarthritis in our patients resulted from congenital dysplasia of the hips. Including other populations in our study might have influenced our results. Sixth, MRI was not performed in all consecutive cases (31.7% of consecutive cases were excluded from this study). Moreover, the timing of post-operative MRI largely varied in our study (6–11 months post-operatively) and this variation might have influenced our results.

Conclusions

In conclusion, we found 13 cases (8%) of TFL atrophy after THA using the modified Watson-Jones approach. However, high BMI can be a risk factor for this nerve injury. The gluteus minimus can be injured directly during surgery in this approach. Avoiding overexposure of the surgical site in cases of high BMI may decrease the incidence of TFL atrophy.

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Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

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