



Investigating the correlation between hip abductor muscle strength and width in anteroposterior pelvic radiographs in hip revision candidates following previous total hip arthroplasty: a cross-sectional study

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Background: The changes in strength of hip abductor muscles after total hip arthroplasty may depend on its anatomical parameters. In the present study the correlation between the strength of the hip abductor muscles before hip revision surgery and the diameter of the abductor muscles in the pelvic anterior posterior X-ray was investigated.

Methods: This cross-sectional study included the patients underwent hip arthroplasty and were candidates for revision surgery. The diameter of the hip abductor muscles on the affected and unaffected sides were calculated based on plain radiography. Patients were also clinically examined and their abductor muscle strength on both sides were determined based on Medical Research Council Manual Muscle Testing scale.

Results: A total of 51 patients were included in the study and after exiting 20 patients; finally 31 patients' data were analyzed. Based on results there was a significant correlation between the ratios of muscle strength and muscle diameter in affected side to unaffected side ($r = 0.517$, $P = 0.003$). As indicated in Table 3, such significant association was revealed in men ($r = 0.719$, $P = 0.001$), but not in women ($r = -0.092$, $P = 0.754$). Also, this relationship was found to be significant in patients older than 60 years ($r = 0.529$, $P = 0.011$), not in the younger.

Conclusion: In patients undergoing total hip arthroplasty revision surgery, there is a strong association between the ratio of strength and diameter of the abductor muscles in the affected side to the unaffected side especially in men and older ages.

Keywords: hip, muscle strength, pelvic bones, X-ray

Introduction

Total hip arthroplasty (THA) is recognized as one of the most successful orthopaedic surgeries, with a success rate of about 95%^[1]. Numerous factors are known as influential factors in the prognosis of this surgery, categorized into two types, patient-related factors, and surgery-related factors^[2]. In various studies,

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HIGHLIGHTS

- One of the challenges of orthopaedic surgeons, especially hip surgeons, is to know the state of muscle strength of patients who undergo total hip arthroplasty revisions.
- In some of these patients, clinical examination is not possible, so surgeons are trying to find a solution for this problem.
- Hip abductors shadow in the pelvic anterior posterior X-rays can be used as a measure of muscle strength.

Regarding patient-related factors, the patient's physical, mental and cognitive condition and underlying diseases were mentioned^[3–5]. These factors are also crucial in THA revision surgeries^[6,7]. Revision of total hip replacements is known as surgery to repair the damaged hip prosthesis. The risk of revision surgery is about 27.6% in 46–50 years, while it is 1.1% in those aged 90–95 years^[8]. There are various reasons for these surgeries, such as repetitive dislocation, infection, and mechanical failures (wear, loosening, breakage)^[1,9]. One of the essential factors in discussing the patient's physical condition before primary and revision of THA is the abductor muscle strength^[10]. Hip abductor muscles include the primary muscles (gluteus medius, minimus, and tensor fascia lata muscle) and the secondary muscles (piriformis, sartorius, and upper fibres of the gluteus maximus),

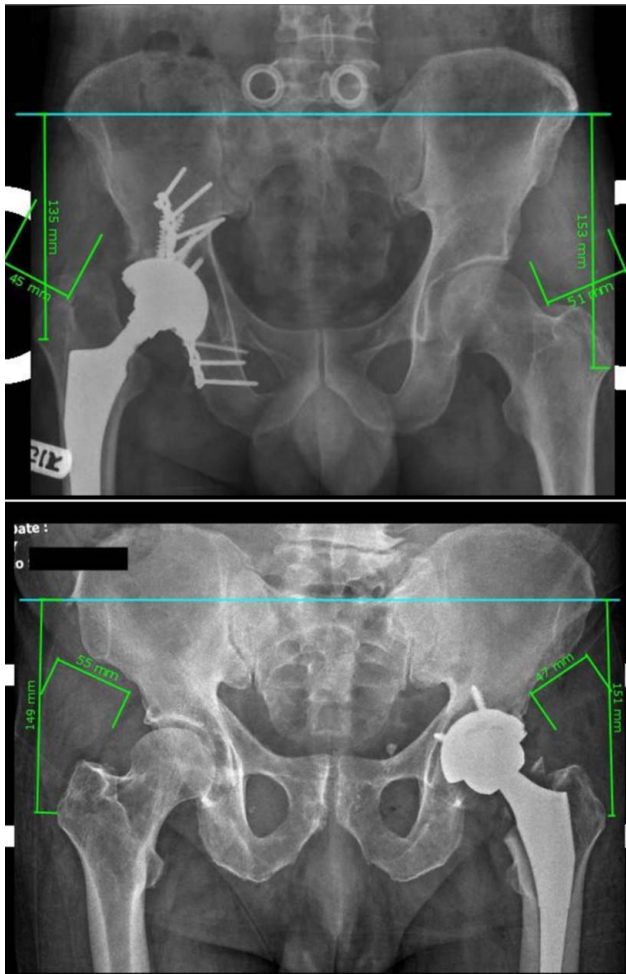


Figure 1. Hip abductor muscles diameter measurement.

which play a vital role in prosthesis stability and patients gait^[11,12]. It has been shown that the weakness of these muscles can increase the risk of falling to mild degrees and cause Trendelenberg gait in more severe degrees^[13,14] Another discussion about the role of these muscles in the outcome of THA surgeries is their mission in limiting prosthesis dislocations^[12]. It means that the weakness of these muscles can lead to events such as falling and joint dislocation^[13], which eventually leads the patient to prosthesis breakage, dislocation, and revision surgeries. However, based on what has been said, one of the permanent limitations for surgeons before the revision of THA surgeries is to examine the strength of the patient's abductor muscles with the whole of limitations like pain due to breakage prosthesis, dislocated hip, infection or other underlying problems^[15–18].

Although various studies have been performed on effective methods in assessing the abductors, using radiologic modalities, including MRI^[19–21], no study has been done on the use of plain radiographic information so far.

This study aimed to investigate the correlation between the abductor hip muscles strength and muscles' width in both affected and non-affected side by using the characteristics of the abductor muscles in an anterior posterior pelvic X-ray.

Materials and methods

Data collection

This cross-sectional study was performed between October 2019 and december2021 on 51 patients who were candidates for revision of total hip arthroplasty at our University Hospital After obtaining approval from the ethics committee of University.

All the patients had only one previous primary total hip arthroplasty at least 6 months ago with the same surgeon and the same method (direct lateral approach with Zimmer Biomet and DePuy synthesis prosthesis).

all of them completed their rehabilitation programme precisely and they were candidates for revision surgery for various reasons.

Patients who were unable to examine (patients with unverified pelvic X-rays, periprosthetic fracture, and nonreducible dislocation) or not willing to participate in the study that was 20 were excluded from the study.

And The study has been reported in line with the STROCSS criteria^[22].

Hip abductor muscles diameter

The diameter of the hip abductor muscles on the affected and unaffected side was measured by one of the authors as an orthopaedic resident on the preoperative pelvis anterior posterior radiograph based on the differences in the density of muscles compared to surrounding soft tissue.

To do this, on the pelvic plain radiograph, a horizontal line was drawn parallel to the superior endplate of the sacrum through both iliac bones (line a- Fig. 1). Then, the distance between line a and the lateral aspect of the greater trochanter and especially the trochanteric ridge (point B) as the insertion of the gluteus medius muscle was measured. Since abductor muscles (gluteus medius and gluteus minimus) run in an oblique direction from the outer part of the ilium toward the greater trochanter, its middle part was chosen as a landmark because it was the widest and the most visible part of the hip abductor muscles (point C).

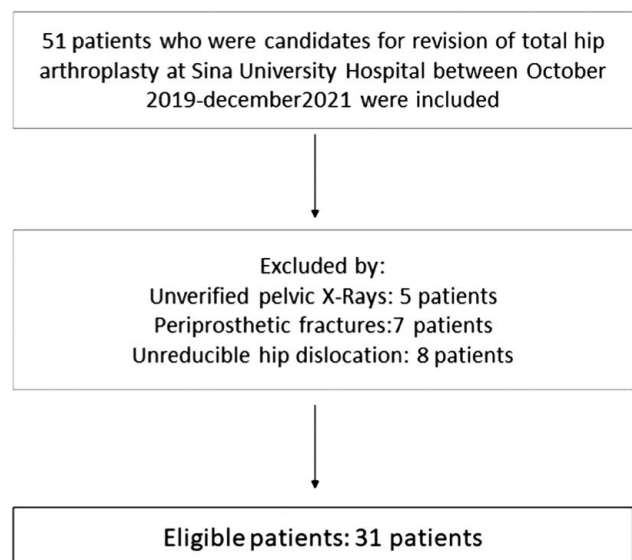


Figure 2. Flowchart of participants in the study.

At this level, the muscle diameter was measured on the widest part of the muscle shadow which is recognized by its density difference with the surrounding tissue (Fig. 1).

Hip abductor muscles strength

Trendelenburg and resisted abducted tests can be used to examine abductor muscles^[23,24]. In our study, we decided to use Resisted abducted test as the method of checking the strength of muscles by principles of the Medical Research Council Manual Muscle Testing scale which specifies the results from zero to five^[25]. Examination and measurement of the abductor muscles strength on both sides was performed by one of authors as an experienced orthopaedic surgeon.

Radiographic evaluation and clinical assessment

The measured diameter of the abductor's muscles in the pelvic X-ray on the affected side is divided by the measurement of the unaffected side and also the strength of muscles on the affected side is divided by the strength of the unaffected side. Then the correlation between the examination results and the diameters of the abductor muscles were studied.

Statistical analysis

For statistical analysis, results were presented as mean \pm SD for quantitative variables and were summarized by frequency (percentage) for categorical variables. The correlation between the parameters was examined using the Pearson's correlation test. *P* values of less than or equal to 0.05 were considered statistically significant.

For the statistical analysis, the statistical software SPSS version 23.0 for windows (IBM) was used.

Result

Data analysis

In the present study, a total of 51 patients were included in the study. Five patients were excluded due to unverifiable pelvic X-rays, seven patients were excluded because of periprosthetic fractures and eight patients were excluded due to nonreducible dislocations, finally, 31 patients remained. (Fig. 2). Among these 31 patients, 17 patients were male (54.8%) and 14 patients were female (45.2%). Patients data were shown in Table 1.

The mean age of patients was 63.78 ± 11.29 years with a range of 33–81 years. Also, women in this study had an average age of about 5 years more than men. BMI was less than 30 in 21 patients and others were 30 or more (Table 2).

The most common reason for the revision was stem loosening which occurred in 48.3% of patients, other causes were cup loosening in 25.8% and dislocation in 25.8%.

The mean ratio of muscle strength on the affected side to the unaffected side (based on examination) was 0.54 ± 0.10 and the mean ratio of muscle diameter on the affected side to the unaffected side (based on radiography) was also 0.69 ± 0.08 in the total population.

As shown in Table 2, the two parameters of muscle strength and diameter were independent of gender and age but there was a significant correlation between the ratios of muscle strength and muscle diameter on the affected side to the unaffected side ($r = 0.517$, $P = 0.003$).

Subgroup analysis (based on gender and age)

As indicated in Table 3, a significant association between the ratios of muscle strength and muscle diameter in the affected side to the unaffected side was revealed in men ($r = 0.719$, $P = 0.001$), but not in women ($r = 0.092$, $P = 0.754$). Also, this relationship was found to be significant in patients older than 60 years ($r = 0.529$, $P = 0.011$).

Discussion

Hip muscle forces undergo significant changes following surgical interventions such as total hip arthroplasty, which is mainly accompanied by recovery after surgery^[26]. Also, changes in muscle mass depend on various factors such as patients' underlying factors, procedural factors, and anatomical parameters^[27,28]. Among the known factors of the hip abductor muscles damage, factors such as hip surgeries, especially if they performed multiple times, inflammation and infection, are also known. And what has been discussed and proven in various studies is the THA surgery from the Harding or the direct lateral approach^[29,30].

Based on the available evidence, it appears that some of the diametric parameters of the hip abductor muscles affect changes in muscle strength as well as the extent and timing of recovery after surgery^[31,32]; however, few studies have been done in this regard.

Determining the strength of hip abductor muscles as trunk stabilizers during ambulation^[33] is important before surgery because it can help determine the best approach for a more rapid return of muscle function and strength and ensure patients' quality of life^[34].

By determining the diameter of the hip abductor muscles and also their strength before surgery, any modification in the lever arm of the muscles could be predicted and the postoperative recovery approach will be planned^[31].

What we found in the present study was a significant difference in the muscle strength and width ratio between affected hip and unaffected hip. Interestingly, such a relationship was affected by the demographic characteristics of patients, including male sex and advanced ages.

Although our results show the significance of the results in the population of men as well as in older people, we cannot comment with certainty on the reason for this because this study is the first time such an investigation has been conducted and for the support of its results certainly requires more studies with a larger population and also with a more detailed examination of the condition and underlying diseases of the patients.

There are very few studies in this regard and fact, this study is the first study of its kind that has evaluated the relationship between the strength of the abductor muscles and the diameter of the relevant muscles in the pelvic X-ray. However, in some studies, factors related to the function and strength of the abductor muscles have been discussed in detail. In a study by Rasi *et al.*^[35], a simultaneous decrease in the diameter of the abductor muscles (from 27.07 mm before surgery to 25.64 mm after surgery) and a decrease in the strength of the corresponding muscles (based on a positive Trendelenburg test) were shown, which could indicate the same changes of both indices in the mentioned patients, but although the evaluation and analysis of the correlation between the two variables were not considered in the study. In a study by

Table 1

Patients data.

Number	Sex	Age	Cause of revision	The ratio of muscle strength (affected/unaffected)	The ratio of muscle width (affected/unaffected)
1	M	51	Dislocation	6/0	78/0
2	F	58	Stem loosening	6/0	68/0
3	M	64	Stem loosening	6/0	74/0
4	M	70	Dislocation	6/0	87/0
5	M	46	Cup loosening	4/0	51/0
6	M	74	Stem loosening	6/0	72/0
7	F	63	Cup loosening	6/0	64/0
8	M	67	Cup loosening	4/0	57/0
9	M	33	Cup loosening	6/0	74/0
10	F	35	Stem loosening	6/0	69/0
11	M	65	Stem loosening	6/0	76/0
12	F	54	Dislocation	6/0	68/0
13	M	73	Stem loosening	6/0	53/0
14	F	71	Stem loosening	6/0	72/0
15	M	81	Dislocation	4/0	57/0
16	F	63	Stem loosening	8/0	78/0
17	F	67	Stem loosening	6/0	74/0
18	M	74	Dislocation	4/0	61/0
19	F	56	Stem loosening	6/0	78/0
20	F	66	Stem loosening	6/0	69/0
21	M	71	Stem loosening	4/0	61/0
22	F	59	Loosening	6/0	72/0
23	F	67	Dislocation	6/0	63/0
24	M	75	Loosening	6/0	79/0
25	M	79	Loosening	4/0	61/0
26	M	63	Dislocation	6/0	81/0
27	F	59	Loosening	4/0	76/0
28	F	62	Loosening	4/0	76/0
29	M	67	Dislocation	6/0	67/0
30	F	72	Loosening	6/0	71/0
31	M	75	Loosening	4/0	65/0

F, female; M, male.

Lanza *et al.*^[36], it was shown that some diametric indices of the abductor hip muscles, including the maximum torque index, were related to the performance test and the corresponding muscle force. In the study of Mahmood *et al.*^[37], a close and significant relationship between femoral offset diameter index and abductor muscle strength was investigated and confirmed. Also, in the study of McGrory *et al.*^[38], the relationship between femoral offset and abductor muscle strength was confirmed. On the other hand, patients who maintained their anatomical lever arm after THA had far better outcomes in terms of abductor muscle strength than patients with changes in the abductor lever arm^[39]. It is clear that the diametric indices of the abductor muscles play a key role in predicting changes in muscle strength after hip surgery, but it is not yet clear which of these factors are most predictive of postoperative muscle strength recovery. However, according to our study, the diameter of the relevant muscles can be a suitable and practical measurement in predicting the strength of the relevant muscles before surgery.

Limitations and strength

This study also had several limitations, a small number of the studied population was one of them, initially, 51 people were included in the study, but after 20 people were excluded, only 31 people were eligible for the study. Another limitation was the high age of most of the patients, which in some of them made it

difficult to communicate with the patients and also make it difficult to examine them. Another problem was with X-Rays, which some of them were of suitable quality for examining and differentiating tissues so we had to exclude them from the study. Another limitation of this study was that in this study, other variables that can affect muscle strength were not taken into consideration, such as the physical condition of the patient before the primary surgery and also before the revision surgery, as well as other factors. Factors such as the patient's underlying diseases and nutritional status were not taken into consideration, which may also have an impact on the conclusion.

But from the strengths of this study, it can be pointed out that so far there has been no study to check muscle strength indirectly

Table 2

Demographic data of the participants.

Demographic data		
Sex, n (%)	Male	17 (54.8)
	Female	14 (45.2)
Body mass index category, n (%)	< 30 kg/m ²	21 (70.5)
	≥ 30 kg/m ²	10 (29.5)
Age(years), Mean ± SD	Male	65.49 ± 2.08
	Female	70.29 ± 1.46
	Overall	63.78 ± 11.29

Table 3
The association of strength and diameter of hip abductor muscles comparing the affected side to the unaffected side.

Subgroup	R coefficient	P value	Mean ratio of muscle strength (affected/unaffected)	Mean ratio of muscle width (affected/unaffected)
Total	0.517	0.003	0.54	0.69
Sex				
Male	0.719	0.001	0.51	0.67
Female	0.092	0.754	0.62	0.71
Age				
< 60 years	0.474	0.198	0.55	0.70
> 60 years	0.529	0.011	0.54	0.69

as an associate to the diameter of hip abductor muscles before surgery using X-ray images as easy, accessible, and inexpensive modalities. In addition to that, paying attention and studying patients who are usually old, and also due to various reasons such as infection and fracture of the prosthesis, it is not possible to carry out a close clinical examination of them is another advantage of this study.

Conclusion

As a conclusion, in patients undergoing revision of THA surgeries, there is a strong association between the ratio of strength and diameter of the hip abductor muscles on the affected side to the unaffected side...

What seems to be considered in future studies is the discussion of paying attention to the primary total hip arthroplasties and also in cases secondary to hip fractures, as well as the discussion of further investigation of the relationship between the diameter of the abductor muscle in X-rays and the examination of the patient.

Ethical approval

Ethical approve was obtained for this study from the ethics committee of Tehran University of Medical Sciences

Consent

Consent to participate was obtained from all patients in the study.

Source of funding

No funding received for this study.

Author contribution

S.H.S.: conceptualization; A.N.: data collection and analysis; B.S.: supervision; M.S.: writing original draft; P.T.: review and editing

Conflicts of interest disclosure

The authors declare that there is no conflict of interest.

Provenance and peer review

Not commissioned, externally peer-reviewed

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