

Original Article

Observation of muscle contracture in patients with femoral head necrosis after hip arthroplasty

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Abstract: *Objective:* The aim of this study was to formulate a rating scale to functionally assess patients with ischemic femoral head necrosis (FHN) who underwent total hip arthroplasty, which was expected to construct a visual and quantitative method for muscle contracture and therapy guiding. *Methods:* The ischemic FHN patients who were admitted in our hospital during September 2015 to September 2016 underwent hip arthroplasty or abduction muscle amputation, and were retrospectively reviewed. The pre- and post-treatment relationship among Harris Hip Score, Visual Analogue Scale (VAS), and Hip Abduction Angle were explored. A rating scale was formulated to assess the muscle contracture at pre- and post-operation of hip arthroplasty, and the patients were grouped according to the scale for corresponding treatment. *Results:* No correlation was found between Harris Hip Score and muscle contracture. According to our self-made rating scale, muscle contracture scale was 4.92 ± 2.361 and 16.24 ± 3.362 at pre- and post-operation respectively, which showed statistical significance ($P < 0.0001$). For the patients scaled at 14-22, the effects of physical treatment were superior to the functional exercise; for the patients scaled at 23-30, abduction muscle amputation showed a superior treatment effect. *Conclusions:* Harris Hip Score could not reflect the condition of muscle contracture. Our self-made rating scale provides a visual and quantitative method for muscle contracture, which could be employed for clinical treatment. Physical treatment and abduction muscle amputation can be employed for the treatment of FHN patients scaled at 14-22 and 23-30, respectively.

Keywords: Femoral head necrosis, hip arthroplasty, muscle contracture, self-made rating scale, abduction muscle amputation

Introduction

Femoral head necrosis (FHN), a clinically common orthopedic disorder, can be divided into traumatic and non-traumatic forms [1]. On FHN treatment, a clinical consensus was made on the application of total hip arthroplasty for FHN patients with Ficat above stage III, identifying with the clinical outcome of improved joint functions and decreased local pain [2]. However, certain complications also existed in the patients undergoing the total hip arthroplasty which may result in adverse effects on the clinical outcome [3, 4]. According to clinical experience, it is well known that the muscle contracture of adductor femoris was found in some FHN patients. Moreover, the post-operation muscle contracture could still be present after total hip arthroplasty, no matter whether pre-operation muscle contracture existed or not.

The post-operation muscle contracture was suggestive of poor efficacy of the surgery, resulting in rejection of further treatment. For severe patients, daily activity could be affected by the muscle contracture through induction of muscle imbalances and limiting ranges of hip joint activity. Even serious dislocation of the hip joint could also result. Recently, physical therapy and abduction muscle amputation are the routine treatment choices for muscle contracture, however, no standard criteria for these two methods creates confusion for the physician. Therefore, how to effectively quantitate and assess the muscle contracture of adductor femoris before and after total hip arthroplasty is of great significance for muscle contracture treatment. The Harris Hip scale is commonly employed to reflect the systematic function of the hip joint [5, 6]. However, it is reported to fail to assess the muscle con-

Changes of muscle contracture pre- and post-operation

Table 1. Harris Hip scale, VAS scale and hip abduction angle at pre-operation and 2 month post-operation

Time	Harris Hip scale	VAS scale	Hip abduction angle
Pre-operation	49.14 ationo	1.164 atio	36.62 ation
2 months post-operation	87.89 th po	2.089 th p	30.42 th po
t	17.380	6.254	6.778
P	P < 0.001	P < 0.001	P < 0.001

tracture and no systematic study has been reported about the criteria of muscle contracture. Based on this, we retrospectively analyzed the muscle contracture of adductor femoris in ischemic FHN patients who underwent the total hip arthroplasty during September 2015 to September 2016 in our hospital. Then, we formulated a rating scale to test the diagnosis coincidence and evaluate the state of muscle contracture, which was expected to guide clinical treatment.

Materials and methods

Patients

A total of 136 cases of ischemic FHN patients who were admitted in our hospital during September 2015 to September 2016 were enrolled. All patients underwent the hip arthroplasty in the unilateral FHN and follow-up visit were III or IV according to Ficat Stage classification. Among the patients, 89 were males and 47 were females, with mean age of 66.71 ± 9.21 (range 52-89) yrs. According to the etiology, these patients could be further divided into traumatic type (n=36), hormone type (n=32), alcohol type (n=64) and others (n=4).

FHN and muscle contracture were diagnosed according to criteria of Campbell Osteology, Association for Research Circulation Osseous (ARCO) and American Academy of Orthopaedic Surgeons (AAOS). The inclusion criteria were as follows: A. confirmed diagnosis of FHN; B. first time undergoing the hip arthroplasty; C. willing to participate; D. intact disease history; E. complete follow-up. The exclusion criteria were as follows: A. failure to complete follow-up or incomplete disease history; B. combined with neurological disease resulting in failure to complete the study; C. combined with other limb dysfunction diseases or with the treatment could affect the observation results.

Clinical treatment of hip arthroplasty and abduction muscle amputation

After successful anesthesia, the patient was positioned laterally on their healthy side, with routine disinfection and scrubbing. A lateral straight incision was made

and the incision length was about 10 cm. The subcutaneous tissue and deep fascia were cut to exposure and the gluteus medius and tensor fasciae latae were isolated by blunt dissection. The plate and tractor were applied to expose the anterior joint capsule. "O" type resection of the joint capsule was carried out to expose the femoral neck. Osteotomy was performed at 1 cm proximal to the femur to remove. After exposure of the acetabulum, the round ligament and proliferated glenoidal labrum was cleaned. Then, proper femoral head prosthesis was installed and the incision was closed and sutured layer by layer. In some patients that presented with osteoporosis, a cemented prosthesis was preferred. Routine treatment methods were processed post-operation. The patients were checked with X-ray imaging and ground activity with protection was performed. The weight training was allowed at 1-2 weeks and complete weight training was allowed after 6 weeks.

For patients that experienced the abduction muscle amputation after successful anesthesia, they were supine positioned and bent with limb and knee to abduct the hip. A 2-3 cm length incision was made at the long tendon along the root of the thigh and inner groin. Subsequently, the deep fascia was cut to expose the long tendon and amputation was made at 1 cm distant from the origin point. The long muscle was pulled outward to expose the short muscle and the superficial branch of obturator nerve. Then the amputation was made and the lesion was sutured to close after examination with limb abduction.

Observation methods

The muscle contracture of the patients with FHN who underwent hip arthroplasty between pre- and 2 month post-operation was observed to calculate the incidence. The

Changes of muscle contracture pre- and post-operation

Table 2. Pearson correlation among Harris Hip scale, VAS scale and hip abduction angle

Time	Correlation	Harris Hip scale	VAS scale	Hip abduction angle
Pre-operation	Pearson correlation	1	-0.040	0.133
	Significance		0.815	0.431
2 months post-operation	Pearson correlation	1	-0.098	-0.031
	Significance		0.566	0.853
N (cases)		136	136	136

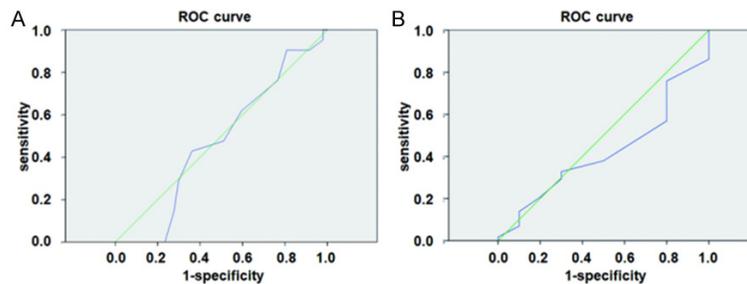


Figure 1. Harris scores and ROC curve of clinical contractile muscle contracture. Pre-operation (A), 2 months after hip arthroplasty (B).

Table 3. Area under the curve at 2 month post-operation by Harris Hip scale

Time	Area	Standard error	Asymp sig	95% confidence intervals	
				Lower	Upper
Pre-operation	0.474	0.072	0.735	0.332	0.616
2 months post-operation	0.422	0.088	0.431	0.250	0.594

relationship among the Harris Hip Scale, Visual Analogue Scale (VAS), and hip abduction angle was observed after hip arthroplasty to analyze the effectiveness of Harris Hip Scale on the assessment of the muscle contracture. Moreover, the muscle contracture rating scale was formulated according to the clinical manifestation and related examination. The effect of hip arthroplasty on the muscle contracture was assessed according to the rating scale table. The rating scale table was also employed to guide the treatment method.

Statistical analysis

All statistical analyses were performed by using SPSS software v.19.0. Quantitative data was expressed as mean \pm standard deviation. Paired t test was used for the pre- and post-operation comparison. $p < 0.05$ was considered as statistical significance.

Results

Association between Harris Hip Scale and muscle contracture

To investigate the association between Harris Hip Scale and muscle contracture, we compared Harris Hip scale, muscle contracture pain and hip abduction angle at pre- and 2 month post-operation (Table 1). The Harris Hip scale at pre- and 2 month post-operation was 49.14 ± 12.68 and 87.89 ± 4.81 , respectively, with an 86.1% total effective rate. Statistical significance was found between pre- and 2 month post-operation ($t=17.380, P=0.000$). Moreover,

a total of 114 patients were evaluated by VAS and the VAS at pre- and 2 month post-operation were 1.16 ± 1.19 and 2.08 ± 1.14 respectively, which showed a statistical significance ($t=6.254, P=0.000$). In addition, hip abduction angle of these 114 patients at pre- and 2 month post-operation was respectively 36.62 ± 5.78 and 30.42 ± 6.05 , which was potently different ($t=6.778, P=0.000$). After hip replacement, the Harris score and VAS score of femoral adductor were higher than those before operation, and the abduction angle of hip joint decreased.

Relationship among Harris Hip scale, VAS and hip abduction angle

In order to unravel the relationship among Harris Hip scale, VAS and hip abduction angle, Pearson correlation was performed with SPSS software. No significant difference was witnessed between Harris Hip Scale, VAS and

Changes of muscle contracture pre- and post-operation

Table 4. Self-made rating scale for muscle contracture assessment

Project	Scoring criteria
Spontaneous pain	0 point Painless, 1 point mild pain, 2 points moderate pain, 3 points severe pain
Adductor Tenderness	0 point Painless, 1 point mild tenderness, 2 points moderate tenderness, 3 points severe tenderness
Limb length change	0 point less than 1 cm, 1 points between 1-2 cm, 2 points between 2-3 cm, 4 points longer than 3 cm
Local tension	0 point no tension, 1 point mild tension, 2 points moderate tension, 4 points hardening or palpable article
Abducent angle	0 point 40 degrees and 1 point plus for each 5 degrees, 8 points 0 degrees
Outward turning angle	0 point 40 degrees and 1 point plus for each 5 degrees, 8 points 0 degrees
Total	30 points

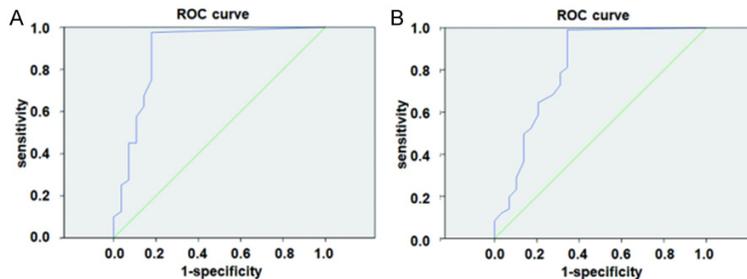


Figure 2. Self-made rating scale scores and ROC curve of clinical contractile muscle contracture. Pre-operation (A), 2 months after hip arthroplasty (B).

Table 5. The area under the curve at 2 month post-operation by self-made rating scale for muscle contracture

Time	Area	Standard error	Asymp sig	95% confidence intervals	
				Lower	Upper
Pre-operation	0.887	0.047	< 0.001	0.794	0.981
2 months post-operation	0.853	0.055	< 0.001	0.705	0.921

hip abduction angle at pre- and 2 months post-operation (**Table 2**). The results of ROC curve showed no significant difference on the diagnostic value of Harris Hip scale between pre- and 2 months post-operation (area under the curve: 0.422, $P=0.084$; **Figure 1**, **Table 3**). These results indicated that there was no correlation between the Harris Hip Scale and muscle contracture, and the Harris Hip scale could not reflect the muscle contracture.

Formulation of the self-made rating scale for muscle contracture assessment

Regarding physical symptoms and related physical examination parameters in muscle contracture including pain, tenderness, touch, limb length, hip abduction and external, we formulated a self-made rating scale in **Table 4**. The total score was 30 with 0-4 representing no muscle contracture, 5-13 represent-

ing mild muscle contracture, 14-22 representing moderate muscle contracture and 23-30 representing severe muscle contracture. According to the observation results, mild clinical presentation without affecting the hip function and cured patients were defined as the scale < 13. Collectively, the scoring table provided a quantitative criterion for evaluating the effect of hip replacement on adductor muscle.

Application of self-made rating scale for muscle contracture

To assess the application of self-made rating scale for muscle contracture, advanced scoring and ROC test was performed for consistency of clinical diagnosis. The results of ROC curve showed there was significant difference on the diagnostic value of self-made rating scale for muscle contracture between pre- and 2 months post-operation (area under the curve: 0.853, $P < 0.001$; **Figure 2**, **Table 5**).

Besides, the score distribution by self-made rating scale showed that 48 cases (35.29%) were with Scale < 4 and 88 cases (64.71%) were with a scale of 5-30 at pre-operation. After treatment, 20 cases (14.71%) were with scale < 4 and 116 cases (85.29%) were with a scale of 5-30 (**Table 6**). According to the results of the rating scale, the muscle contracture scale was increased from 7.92 ± 2.361 at pre-operation to 16.24 ± 3.362 at post-operation, which showed a statistical significance ($t=33.992$, $P < 0.001$) (**Table 7**). Furthermore, femoral head necrosis was often associated

Changes of muscle contracture pre- and post-operation

Table 6. The scores distribution pre- and post-operation by self-made rating scale

Time	0-4 points (cases)	5-14 points (cases)	15-22 points (cases)	23-30 points (cases)
Pre-operation	48 (35.29%)	47 (34.56%)	22 (16.18%)	19 (13.97%)
2 months post-operation	20 (14.71%)	29 (21.32%)	59 (43.38%)	28 (20.59%)

Table 7. The scores comparison of pre- and 2 months post-operation by self-made rating scale

Time	Rating scale scores	t	p
Pre-operation	7.92operat	-	-
2 months post-operation	16.24ths po	33.992	<0.001

with adductor contracture and hip replacement could aggravate the extent of adductor contracture.

Comparison of self-made rating scale and Harris Hip score

To further assess the application of our self-made rating scale, femoral adductor contracture before hip replacement in patients with osteonecrosis of the femoral head was measured and compared. The patients were grouped according to the score: group A 0-4, group B 5-14, group C 15-22, and group D 23-30. There was no difference in factors such as gender, age, and the causes of the disease. The adductor contracture score 3 months after hip replacement in the four groups calculated by both methods all were higher than those before surgery. Three months after operation, group D had the highest self-made rating scale but the lowest Harris score. There was statistical significance compared with the other three groups (**Table 8**). According to the group of adductor contracture of different shares, hip replacement aggravated the extent of adductor contracture.

Discussion

With the advancement of medical technology, how to effectively maintain the relative body function after hip arthroplasty is urgently required. Some of the previous neglected complications are gradually attracting focus by the clinician and the muscle contracture is one of these complications after hip arthroplasty [7]. A previous study pointed to the presence of prosthetic dislocation [8] in those patients with muscle contracture. The main clinical manifestations included hip pain

and limited activity restriction in FHN patients [9]. Severe FHN could be presented after hip arthroplasty, which could result in femoral head collapse, shorted limb, limited activity, and severe ache. The shortening femoral head could induce contracted muscle,

increased pain and decreased activity ability, which aggravates the muscle contracture [10]. The application of intraoperation anesthesia and muscle relaxation drugs maintains the muscle in a relaxed state, which facilitates the traction and placement of the prosthesis. After recession of the anesthesia and muscle relaxation drugs at post-operation, the shorted limb could be rectified and the adductor muscle was recovered into a stretch state, which resulted in acute and sustained adductor muscle strain, edema or aseptic inflammation, myofascial degeneration fibrosis and even linear and nodular materials, finally the severe adductor muscle contracture. Therefore, the adductor muscle contracture could be presented at pre- or post-operation time point of hip arthroplasty.

The Harris hip scale is currently employed for observation of the FHN in clinical practice. The Harris hip scale is an effective measurement method for the entire hip function, but could not be described accurately on the detailed location. In the present study, we obtained a Harris scale of 87.89 ± 4.81 and a total effective rate of 86.1%, which were consistent with a previous report [11]. According to these results, clear surgical effects could be identified, which could rule out the possibility that the muscle contracture was caused by a technical problem of the surgeons. In the present study, we also found strikingly increased VAS scale and decreased hip abduction angle after the hip arthroplasty, indicating the influence of muscle contracture by the hip arthroplasty. There are several reasons for the pain presented after hip arthroplasty [12], such as infection, prosthetic loosening, wear particle stimulation, dislocation, heterotopic ossification, and the different length of lower limbs. These pains were often more intense, but the group of mild muscle con-

Changes of muscle contracture pre- and post-operation

Table 8. The scores of the patients in each group at pre- and 2 months post-operation by self-made rating scale

Group	Cases	Pre-operation by self-made rating scale (scores)	2 months post-operation by self-made rating scale (scores)	Pre-operation by Harris Hip scale (scores)	2 months post-operation by Harris Hip scale (scores)
A (0-4)	48	1.103 ± 0.549	2.29 ± 2.253	51.57 ± 12.300	90.83 ± 5.321
B (5-13)	47	6.640 ± 2.549	13.57 ± 2.895	51.37 ± 9.679	90.09 ± 5.351
C (14-22)	22	17.38 ± 2.941	21.76 ± 4.426	48.63 ± 11.791	90.11 ± 4.879
D (23-30)	19	24.60 ± 2.741	26.55 ± 1.638	45.57 ± 10.679	80.93 ± 5.009
Total	136	7.92 ± 2.361	16.24 ± 3.362	49.14 ± 12.681	87.88 ± 4.135

tracture was with a low post-operation VAS scale (2.08 ± 1.14), so the muscle contracture could easily be covered by these fierce ache [13-16]. On the Harris Hip Scale, the activity of hip joint was composed by several aspects and only a very low ratio was taken up by Hip Joint Angle. Therefore, the hip abduction angle could not reflect impact of muscle contracture. According to the Pearson correlation results, no statistical significance was found among the Harris Scale, muscle contracture VAS scale, and hip abduction angle at pre- and post-operation. The results of ROC curve showed that the area under the curve was 0.422 ($P=0.084$), indicating Harris Hip Scale could not be used for muscle contracture assessment. However, it is incomplete to employ VAS scale or abduction angle alone to assess the muscle contracture, meanwhile other presentation of muscle contracture could not effectively reflect either. Moreover, the relationship among different parameters could not effectively be expressed. According to the previous study, the presence of muscle contracture could not be used as an indicator for observation. Therefore, it is important to formulate a novel, quantified assessment table which could directly reflect the muscle contracture degree for related research and guide of the clinical treatment.

Based on the long-term clinical observation and repeated study, we found that muscle contracture mainly presented as mild pain. In spite of the increased post-operation ache, the VAS was no more than 3 points. Due to the mild pain presented in muscle contracture, the local tenderness could reflect muscle contracture more effectively. Therefore, the above two parameters were included in the assessment table. More severe muscle contracture results in more tense, decreased elasticity and even the presence of local linear material and local

sclerosis. Therefore, these indexes could also be included in the assessment table. In the present study, the muscle contracture was related to shorted limbs [17]. Shorted limb resulted in muscle contracture in a degree dependent manner and this index could be included in the self-made assessment table. Muscle contracture could affect the hip abduction and external activity leading to more severe muscle contracture, more recession of hip abduction, and external function. Furthermore, severe hip and knee bending could present with positive adhesive knee signs. Therefore, these two indexes were of great importance for muscle contracture assessment; negative correlation could also be found between muscle contracture and hip abduction. Regarding this, a higher scale reflected a lower activity in the assessment table. After multiple statistical analyses and adjustments, several parameters included in this table could be employed for assessment of the muscle contracture after hip arthroplasty.

From the assessment table, 64.71% FHN patients were combined with moderate and severe muscle contracture at pre-operation time point and this number was increased to 85.29% at post-operation. The rating scale was 7.92 ± 2.361 and 16.24 ± 3.36 at pre- and post-operation in self-made assessment table, respectively, which showed statistical significance and consistent with clinical observation, indicating the great influence of the hip arthroplasty on muscle contracture. It is necessary to avoid the continued risk factors involved in the hip arthroplasty induced by the muscle contraction.

Active therapeutic modalities should be employed in the FHN patients with muscle contracture. In the present study, we applied func-

Changes of muscle contracture pre- and post-operation

tional exercise, physical treatment, and abduction muscle amputation as treatment methods and improved conditions could be found in the patients with muscle contracture. In the patient with a scale lower than 13, no impact could be found on the hip function and no particular treatment was needed. Therefore, we employed functional exercise as the treatment choice. In the patients with a scale of 14-22 and moderate muscle contracture, both function treatment and physical treatment could be employed as therapeutic choice. According to the therapeutic results and total effective rate, significant differences could be found and physical treatment was superior to the function exercise. Therefore, physical treatment could be employed for the moderate muscle contracture. For the patients with a scale of 23-30 and severe muscle contracture, physical treatment and muscle contracture amputation could be employed as the treatment modality. Significant statistical difference could be found on the treatment results and total effective rate, and superior results could be found in the adductor muscle amputation group than physical treatment group. Therefore, adductor muscle contracture is the first choice in the patients with severe muscle contracture.

There are also some limitations in present study. A property of retrospective studies could result in incomplete patient selection, follow-up, and sample number, and further improvements are required for the clinical study in the near future.

In conclusion, our rating scale table showed the advantages including reasonable design, direct and quantitative reflection of the muscle contracture at pre- and post-operation of hip arthroplasty, which could also be used for the treatment guiding after the hip arthroplasty or other type of muscle contracture. How to effectively employ this table to assess the requirement of adductor muscle amputation after the hip arthroplasty is of great clinical significance.

Disclosure of conflict of interest

None.

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Changes of muscle contracture pre- and post-operation

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