Muscular Recovery of Hip Flexors and Extensors after Two-incision Total Hip Arthroplasty

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Background: The influence of two-incision total hip arthroplasty on muscular function has not been reported. We hypothesized that recovery could be different for the hip flexors and extensors because an intermuscular interval was used in the flexors but a trans-muscular approach was used for the extensors.

Methods: Two-incision total hip arthroplasties were performed in 10 patients (8 men and 2 women) with a mean age of 47.2 years (range, 27 to 63 years). Muscle torques were measured prospectively in the 10 patients using a cybex dynamometer preoperatively, 6 weeks postoperatively, and at the latest follow-up.

Results: It was found that muscle torque improved from 0.51 (preoperative) to 0.68 Ft-Lbs/Lbs 6 weeks postoperatively. ($p = 0.007$) However, this improvement was contributed by the flexors but not the extensors. In contrast to the flexors, the torques of the extensors significantly decreased to 86%, 78%, and 63% at the angular velocity of 60°/min, 90°/min, and 180°/min, respectively, 6 weeks postoperatively. At the most recent follow-up (average 40 ± 2 months), differences could not be found in either the flexors or the extensors compared with the unaffected side.

Conclusion: The causes for the delayed recovery of hip extensor muscles could be related to surgical techniques that traverse the muscle during femoral canal preparation and stem implantation. This study suggests that the two-incision technique can be further refined in view of the muscular function.

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Key words: muscle torque, minimally invasive, two-incision, arthroplasty

Minimally invasive two-incision (MIS-2) total hip arthroplasty (THA) has created much controversy among orthopaedic surgeons and a great deal of publicity in the popular press. Rapid rehabilitation, less pain, and quicker functional recovery have been reported.[1,2] However, adverse reactions and early complications have also been reported from centers experienced in joint replacements.[3-5] In one report, the results of the MIS-2 technique were apparently poorer than the posterior approach in THA, with modest outcomes and substantial complications.[6]

The MIS-2 THA uses different surgical planes for prosthesis implantation. The anterior incision is made between the muscular interval of the tensor fasciae latae and the sartorius superficially and between the gluteus medius and the rectus femoris underneath. The posterior incision traverses the glu-

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teus maximus and is similar to that described for the insertion of an intramedullary femoral nail.[7] The MIS-2 technique has been claimed to have rapid functional recovery because soft tissue injury is minimized.[1,2] In the literature, influence of the MIS-2 technique on muscular function remains hypothetical and lacks evidence-based information. Although the two-incision technique is taken as a muscle-sparing procedure, damage to the gluteus muscle and external rotators has been demonstrated in a cadaver study.[8] Since the anterior incision uses the intermuscular interval but the posterior incision traverses muscles by a blunt method, we hypothesized that recovery of muscular function would be different in the hip extensors and hip flexors. The purpose of this study was to investigate how the muscular function of the hip flexors and extensors were affected by the two-incision technique.

METHODS

From October to December 2003, 10 patients undergoing MIS-2 THA were included in the study after giving informed consents. The inclusion criteria were unilateral hip disease and a normal contralateral hip. There were 8 men and 2 women with a mean age of 47.2 years (range, 27-63 years). The diagnosis was osteonecrosis of the femoral head in 7 patients and osteoarthritis in 3 patients. The cases of osteoarthritic hips were not associated with severe dysplasia (Crowe III and IV) which would confound the results of muscular recovery. The body mass index (BMI) of the patients ranged from 21.0 to 25.7 (mean, 23.1).

In these 10 patients, cementless total hip replacements using the Triology cup (Zimmer, Warsaw, IN, U.S.A.) and the Fiber Metal Taper stem (Versys, Zimmer, Warsaw, IN, U.S.A.) were performed by the two-incision method. (Fig. 1).

After the operation, functional assessment and radiographic examination were performed at 3 weeks, 6 weeks, 3 months, 6 months, and 1 year, and yearly thereafter. The cup abduction angle, anteversion angle, difference in leg length, ratio of offset (operated side/non-operated side), and stem alignment were recorded.[9] Hip function and quality of life were assessed with use of the Harris hip score[10] and the Western Ontario and McMaster University

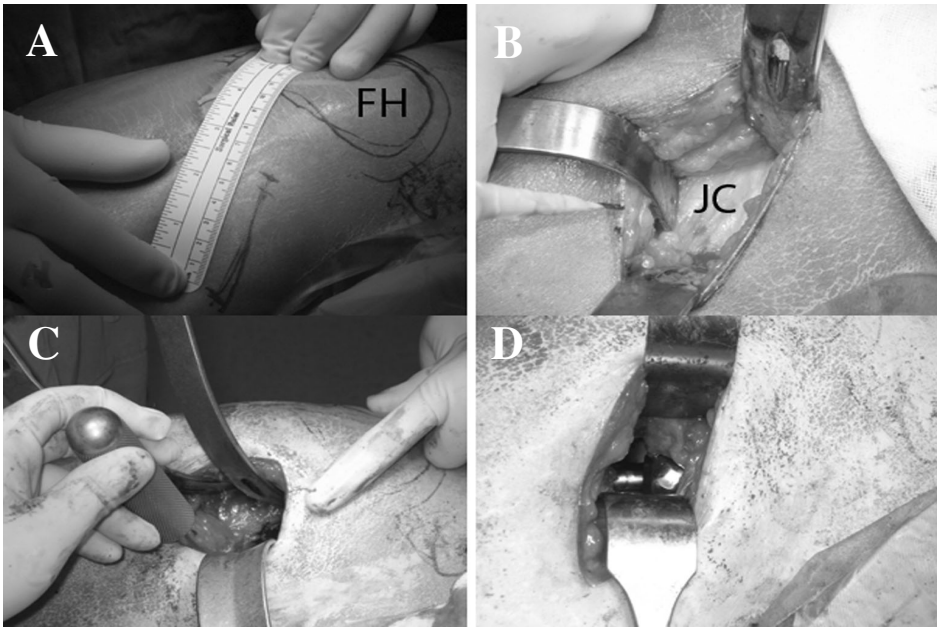

Fig. 1 Surgical approach for the two-incision total hip arthroplasty. (A) An anterior skin incision is made spanning the femoral neck about 4 fingerbreadths below the femoral head. (B) The joint capsule is exposed between the sartorius muscle and the tensor fasciae latae muscle. (C) The posterior incision is located from the anterior wound with a curve-tipped indicator. (D) Final assembly of the prosthesis.

Osteoarthritis Index (WOMAC).[11]

The muscle function study was done with a cybex dynamometer in every patient[12] (Cybex 340 dynamometer, Cybex, New York, U.S.A.) at the angular velocities of 60°/min, 90°/min, and 180°/min for the hip flexors and extensors. Testing was done on the affected (diseased) and the unaffected (sound) side both preoperatively, 6 weeks postoperatively, and at the most recent follow-up (average 40 months, range 37 to 44 months). The peak isometric torque strengths in combination of flexion and extension of the hip muscles were measured first. The muscle torques at the angular velocities of 60°/min, 90°/min, and 180°/min were then separately tested on the flexors and extensors with flexion in the supine position and extension in the prone position based on the clinical, manual muscle test (MMT) position. Each test was equilibrated by a preconditioning step involving concentric movements of the hip joint and was repeated 3 times to avoid muscle fatigue. The hip abductors, adductors, and internal and external rotators were not tested in this study. Data acquisition was collected by synchronizing the cybex dynamometer with a personal computer. The nonparametric Wilcoxon signed-ranks test was used to compare the side-to-side differences and the preoperative-postoperative differences in the peak muscle torques. Repeated -measures ANOVA was used to compare the changes in muscle torques of the flexors and extensors tested at different angular velocities. A *p*-value less than 0.05 was considered statistically significantly.

RESULTS

The mean operation time was 183 minutes (range, 95-345 min). The mean blood loss was 815 mL (range, 100-1250 mL). The mean wound length combining the two incisions was 9.5 cm (range, 8.5-10 cm). The mean hospital stay was 5.5 days (range, 4-8 days). There was no perioperative mortality, fatal pulmonary embolism, fracture or dislocation, or vascular injury in these 10 cases. Two patients complained about temporary paresthesia of the lateral femoral cutaneous nerve during follow-up. The symptoms resolved within 6 months. The average cup inclination angle was 42.5 ± 2.9 degrees. The average cup anteversion angle was 17 ± 3.8 degrees. The average leg length difference was 1.0 ± 2.4 mm postoperatively. The average ratio of offset was 0.99 ± 0.02 postoperatively. The average Harris hip score improved from 63.1 ± 7.3 preoperatively to 86 ± 7.5 at 3 weeks, 93.8 ± 5.4 at 6 weeks, 96.6 ± 4.2 at 3 months, 99.2 ± 1.6 at 6 months, 98 ± 4.4 at 1 year, and 97.8 ± 5 at 2 years. The average WOMAC scale improved from 66.7 ± 13.2 preoperatively to 91.8 ± 3.3 at 3 weeks, 94.1 ± 3.6 at 6 weeks, 96.2 ± 3.9 at 3 months, 97.7 ± 4.5 at 6 months, 97.5 ± 5.3 at 1 year, and 98 ± 5.3 at the latest follow-up.

Preoperatively the peak muscle torque of the affected hips was significantly lower than that of the unaffected hips. (p = 0.005) At 6 weeks after the MIS-2 THA, the changes in peak muscle torque of the affected hips improved from 0.51 Ft-Lbs/Lbs to 0.68 Ft-Lbs/Lbs (p = 0.007) and approached the levels of the unaffected side (p = 0.184). The deficit of peak muscle torque was significantly improved from 24% preoperatively to 4% postoperatively (Table 1). The muscle torques of the hip flexors and the extensors were further analyzed separately. At 6 weeks postoperatively, the muscle torques of the hip flexors were either restored or improved significantly and approximated the preoperative levels of the affected side at the angular velocity of 90°/min (recovery to 101% of preoperative levels) and 180°/min (recovery to 102% of preoperative levels). In contrast, the muscle torques of the hip extensors were significantly weaker at the angular velocity of 60°/min, 90°/min, and 180°/min (Table 2). At the most recent follow-up (average 40 ± 2 months), no differences could be

Table 1. Changes in Peak Muscle Torque of the Hip before and after MIS-2 THA

	Preoperative (Ft-Lbs/Lbs)†	Postoperative (Ft-Lbs/Lbs)†	Postop-to-Preop difference *p*-value‡
Unaffected (sound) side	0.68 ± 0.14	0.71 ± 0.14	0.09
Affected (diseased) side	0.51 ± 0.10	0.68 ± 0.16	0.007
% of deficit*	24 ± 8	4 ± 10	0.009
Side-to-side difference *p*-value	0.005	0.184	

Data are presented as mean ± standard deviation.
*: % of deficit = [(unaffected side - affected side)/unaffected side] x 100; †: Ft-Lbs/Lbs = Feet-pounds per pound of body weight; ‡: Wilcoxon signed-ranks test.

Table 2. Effects of MIS-2 THA on Muscle Function in the Hip Flexors and Extensors Determined by Cybex Dynamometer

	Preoperative (Ft-Lb)	Postoperative (Ft-Lb)	Recovery %	*p*-value*
Hip Flexors				
Angular velocity 60°/min	35.18 ± 6.71	31.26 ± 7.61	89	0.034
Angular velocity 90°/min	32.09 ± 5.64	32.50 ± 8.96	101	0.836
Angular velocity 180°/min	33.54 ± 9.00	34.26 ± 9.13	102	0.440
Hip Extensors				
Angular velocity 60°/min	27.18 ± 6.11	23.50 ± 5.65	86	0.026
Angular velocity 90°/min	25.01 ± 5.37	19.50 ± 6.58	78	0.001
Angular velocity 180°/min	20.91 ± 3.97	13.25 ± 6.00	63	0.001

Abbreviation: MIS-2 THA: minimally invasive two-incision total hip arthroplasty; *: Repeated -measures ANOVA.
Data are presented as mean ± standard deviation.

found in either the flexors or the extensors compared with the unaffected side (data not shown).

DISCUSSION

Total hip arthroplasty is the standard treatment for various hip diseases. The primary goals of THA are to relieve incapacitating pain and to facilitate functional recovery.[13-15] With prolonged disuse, the hip and thigh muscles often become atrophic in most patients. After THA, the disused or atrophic muscles should gradually recover. During the recovery period, protective weight bearing with a walking aid is usually recommended for cementless THA. The period usually takes about 3 months and allows bone ingrowth and recovery of muscle strength to prevent accidental falls after the THA.[16,17]

In a previous study, significantly weaker torque strength around the hip joint was found even 1 year after THA with a posterior approach.[12] Kinematic studies such as gait analysis also demonstrated that six months following THA using a standard anterolateral or posterior approach, the majority (85%) of patients did not have a normal gait pattern.[18] However, the recent introduction of minimally invasive THA challenges these practice guidelines. Rapid recovery has been reported with different surgical techniques.[1,2,19-25] In one report, THA could even be done on an outpatient basis.[2] Whether the speedup of rehabilitation can be attributed to the rapid recovery of muscle function because of less tissue trauma is not clear.

The MIS-2 THA technique uses two different incisions for prosthesis implantation. Rapid recovery has been observed.[1-3] Increased complications with delayed recovery have also been reported.[3-6] In this study, we used the MIS-2 technique and prospectively performed cybex studies to check the torque strength of the hip flexors and extensors preoperatively and 6 weeks postoperatively. The period of 6 weeks postoperatively is of particular interest because many surgeons believe that patients should discard crutches as early as possible after minimally invasive THA.

We noticed the torque strength of the hip flexor muscles was significantly restored to the levels of the unaffected side at 6 weeks postoperatively. This was different from a previous study in which the hip flexors remained weaker than the unaffected side one year after surgery with a standard approach.[12] This delayed recovery could be related to the release of the iliopsoas tendon in conventional methods in some cases. The current method of a minimally invasive posterior approach minimizes muscular cutting on the external rotators and spares the hip flexor and abductor musculature. Delayed recovery of the hip flexor is less likely to happen in cases using the current minimally invasive posterior approach.

On the other hand, rapid recovery of the hip extensor muscles was not seen in this study. The torque strength of the hip extensors was significantly decreased, not only compared to the unaffected side at 6 weeks postoperatively but also compared to preoperative levels. The muscles responsible for flexion

of the thigh include the iliopsoas, anterior fibers of the gluteus medius, the gluteus minimus, the tensor fasciae latae, the sartorius, the rectus femoris, the pectineus, and the adductors. The muscles responsible for extension of the thigh include the gluteus maximus, posterior fibers of the gluteus medius, and the hamstring muscles (biceps femoris, semitendinosus, and semimembranosus muscle). The anterior incision of the MIS-2 technique seems quite favorable for recovery of the hip flexors in this study. However it appears unfavorable for recovery of the hip extensors. Preparation of the femur for stem implantation requires blunt dissection of the gluteus maximus, repetitive reaming and broaching, and jamming of the femoral stem through a small stab wound. In a cadaver study, Mardones et al. demonstrated that these steps substantially damage the abductors and external rotators of the hip.[8] The delayed recovery of the hip extensors observed in this study is similar to that in reports of antegrade intramedullary nailing of the femur, in which a significant number of patients also had muscular dysfunction after blunt injury to the gluteus maximus.[26,27]

In this study, no control groups were tested for comparison of muscle recovery using different approaches. This study investigated how the hip muscles are affected by the MIS-2 approach and did not make comparisons with other surgical methods. The advantages or disadvantages of different surgical approaches for THA could only be objectively analyzed by a perspective randomized clinical trial.

In this study, only 10 paired data were available for analysis. However, the preoperative torque strengths of the hip flexors and extensors were similar to a previous study with 40 recruited cases.[12] Although the sample size was small, we discovered that delayed recovery of the hip extensors could result from the two-incision technique. This finding is important because delayed recovery of the hip extensors from the MIS-2 approach has not been reported before. Hip extensors are important muscles for hip functions such as rising from a sitting position, stair climbing and walking. Although complete recovery of muscle torque was found at an average follow-up of 40 months, the current study implies that the MIS-2 technique might not be a complete muscle-sparing approach, particularly for the hip extensors at 6 weeks. Since we can not know the time needed for complete recovery of the hip extensors from the results of this study, protective weight bearing after the MIS-2 THA should still be encouraged in the early postoperative period for a minimum of 6 weeks.

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雙刀口人工髖關節置換手術對髖部伸展與屈曲肌肉功能的影響

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背 景： 雙刀口人工髖關節置換手術對於肌肉組織功能的影響，在文獻上仍未有報告。由於手術的刀口在前側是利用肌肉組織間隙，而在後側是直接穿過肌肉組織，因此我們假設髖關節前側的屈曲肌肉與後側的伸展肌肉在手術後的恢復狀況將會有所不同。

方 法： 十位平均年齡 47.2 歲的病人，在接受雙刀口人工髖關節置換手術前、手術後 6 週，以及最後一次追蹤時接受肌肉扭力測試 (cybex dynamometer)，以探討肌肉功能恢復的情形。

結 果： 手術 6 週後髖關節的肌肉扭力，從術前的 0.51 Ft-Lbs/Lbs 進步到 0.68 Ft-Lbs/Lbs (p = 0.007)，然而肌肉扭力進步的主要原因是來自髖部屈曲肌肉功能的恢復，而不是伸展肌肉的恢復。因爲在角速度 60°/min、90°/min，及 180°/min 的測試下，髖部伸展肌肉的扭力在手術後 6 週時分別下降到手術前的 86%、78%，及 63%。在平均 40 ± 2 週時則不論屈曲或伸展肌肉的扭力都與正常側沒有明顯的差異。

結 論： 雙刀口人工髖關節置換術後，髖部伸展肌肉的功能恢復在 6 週時明顯的比手術前降低，而髖部屈曲肌肉則有顯著的功能復原。原因可能是與手術後側切口直接穿過髖部伸展肌肉，並與股骨骨髓腔鑿孔和人工股骨柄植入步驟有關。本研究顯示雙刀口手術在有關肌肉功能恢復方面，仍然有改善的空間。

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關鍵詞： 肌肉扭力，微創，雙刀口，關節置換

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