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External Snapping Hip Treated by Effective Designed N-plasty of the Iliotibial Band

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Purpose: The purpose of this study is to present the effective design of N-plasty of the iliotibial band and surgical results of its use as a treatment for refractory external snapping hip.

Materials and Methods: We evaluated 17 patients (24 cases) with external snapping hip who underwent N-plasty between October 2013 and May 2016 and who were followed up for at least 12 months. All patients were male and the mean age was 20.8 years. The mean duration of symptoms prior to surgical intervention was 28.5 months with an average follow up of 24.5 months. Surgery was defined as being successful when patients could carry out their daily activities and exercise without a clicking sensation or pain 6 months after surgery until their last follow-up. Failure was defined when either a clicking sensation or pain was present. The visual analog scale (VAS) and modified Harris hip score (mHHS) were measured and compared preoperatively and at last follow-up.

Results: All patients had complete resolution of pain and snapping. The VAS decreased from 6.77 preoperatively to 0.09 postoperatively and mHHS improved from 69.5 to 97.8 after surgery.

Conclusion: Modified designed N-plasty is considered to be an excellent treatment method facilitating operation reproducibility with maximum elongation effect of the iliotibial band.

Key Words: Iliotibial band, External snapping hip, N-plasty

INTRODUCTION

Snapping hip syndrome is characterized by an audible, visible or palpable snap produced during motion of the hip and/or a snapping sensation which may be accompanied by pain. The etiology of snapping hip is anatomically divided into intra- and extra-articular causes, with extra-articular snapping being further subdivided into external and internal types[1-3]. Of these, external snapping, the most common type of snapping hip, is caused by an enlarged or tight posterior portion of the iliotibial band (ITB) and tight anterior border of the tendinous insertion of the gluteus maximus muscle, releasing a snapping sound when the ITB slides over and catches on the superior border of the greater trochanter of the femur as the hip is flexed or extended, or internally/

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externally rotated[1-6]. In most cases, symptoms are resolved with conservative treatments (e.g., restricted physical activity, physical or drug therapy, and local steroid injection), but surgical intervention is needed for patients refractory to conservative treatments[2,4,6,7]. Among multiple surgical techniques introduced previously, favorable clinical outcomes have been reported using N-plasty lengthening of the ITB[1,3] by making an N-shaped incision in the ITB vertical to the fibers of the gluteus maximus muscle and involving a cross-stitch suture.

When N-plasty was initially performed, there were differences in sutured patterns according to preoperative design. When incisions were extended transversely or distally due to inconsistent incision design, we applied incision shapes similar to the suture site of Z-plasty or incomplete suture. When design of N-plasty may differs by surgeon, the degress of elongation may be different. For this reason, a uniform design was needed to have maximum elongation effect of the ITB. Therefore, the authors carried out N-plasty by developing a uniform design and retrospectively reviewed patients with external snapping hip recalcitrant to conservative treatment. The aims of this study are (1) to present an effective design for N-plasty and (2) to report the surgical results of newly modified N-plasty.

MATERIALS AND METHODS

1. Subjects

We retrospectively reviewed 17 patients (24 cases) who, between October 2013 and May 2016, presented with severe pain and a clicking sensation due to external snapping hip refractory to about 3 to 4 months of conservative treatment. Of the 24 cases that underwent N-plasty by a single surgeon, 20 were followed up for more than 12 months. All patients were male soldiers on active service with a mean age of 20.8 years (range, 20-22 years). The subjects had no systemic comorbidities and those with a history of childhood pathological sequelae, fracture or surgery which could have affected the hip were excluded. All patients complained of repetitive pain accompanied by an audible snapping noise over the greater trochanter; the clicking was externally visible in 18 cases. The mean duration from symptom onset to hospital visit for surgical intervention was 28.5 months (range, 2.8 months-10 years) with an average follow-up of 24.5 months (range, 8-24 months) (Table 1). With respect to onset area, 3 and 7 cases were on the right and left side, respectively; the remaining 7 patients (14 cases) were bilateral in nature and all received surgical treatment on both sides.

2. Methods

We investigated preoperative symptom duration and medical history. The Ober's test was performed to assess for tightness of the ITB. To assess snapping, patients were placed in a side-lying position with the affected hip facing up. Next, the greater trochanteric region was palpated with repetitive hip flexion and extension while the hip was adducted and the knee was extended for tightness in the ITB. In addition, patients were evaluated for the presence of pain and snapping (palpable and/or auditory). We excluded

Table 1. Descriptive Statistics of Quantitative Variables

Characteristic	Value	*P*-value*
Demographic results		
Patient/case	17/24	
Age (yr)	20.8 (20-22)	
Time between development of symptom and surgery (month)	28.5 (2.8-120)	
Follow-up duration (mo)	18.2 (8-24)	
Clinical and measurement outcomes		
Pre-operative VAS	6.77 (6-9)	0.001
Post-operative VAS	0.09 (0-2)	
Pre-operative mHHS	69.5 (44-82.5)	0.001
Post-operative mHHS	97.8 (92.4-100)	
ITB posterior margin thickness (mm)	7.2 (5-16)	
Longitudinal elongation length of ITB (mm)	26.4 (20-40)	

Values are presented as number only or mean (range).
VAS: visual analogue scale for pain, mHHS: modified Harris hip score, ITB: iliotibial band.
* Based on Wilcoxon signed rank test; $P<0.05$ demotes statistical significance.

cases with snapping hip caused by fibrosis of the gluteus maximus by evaluating popping noise with the knee flexed[7]. In addition to physical examination, diagnosis was made using magnetic resonance imaging (MRI) in all cases (Fig. 1).

Surgery was considered successful when patients were able to perform daily activities and exercise without a clicking sensation or pain from the 6th postoperative month to last follow-up. Failure was defined when either a clicking sensation or pain was present[1,3]. To evaluate clinical results, the degree of hip function improvement was assessed using the visual analog scale (VAS) and modified Harris Hip score (mHHS) by comparing pre- and post-operative scores.

Statistical analyses were performed using PASW Statistics software version 18.0 (IBM Co., Armonk, NY, USA). Pre- and post-operative VAS and mHHS were compared by using non-parametric test and Wilcoxon signed rank test. *P*-values of less than 0.05 were considered statistically significant.

This study was performed after gaining the approval from Institutional Review Board of Soonchunhyang University Cheonan Hospital (IRB No. 05-2017-035).

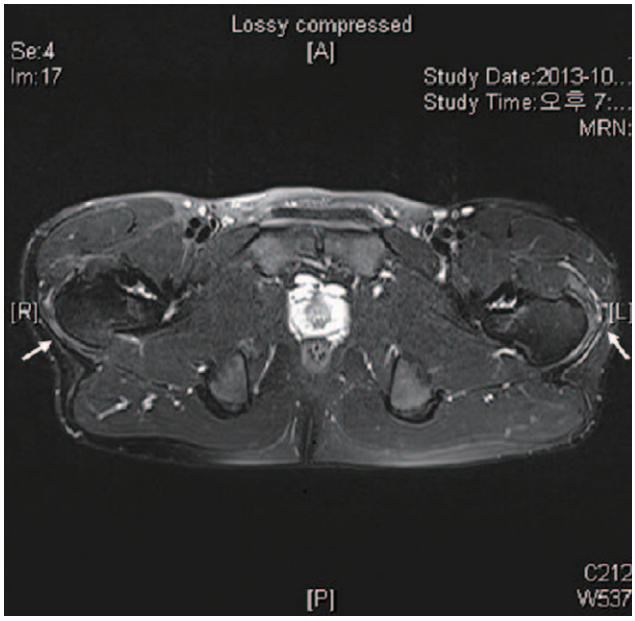

Fig. 1. Magnetic resonance imaging (MRI) examinations. A 21-year-old man with bilateral snapping hip syndrome. The T2-weighted MRI of both hips show thickening and fibrosis of the iliotibial band and greater trochanteric bursitis (arrows).

3. Surgical Methods

All patients received surgery in lateral decubitus position under general anesthesia (3 cases) and spinal anesthesia (21 cases). Surgical management was performed in all cases using N-plasty as proposed by Yi et al[1]. While the patient was positioned in a side-lying position under anesthesia, the area where the ITB caught on the greater trochanter was palpated with the hip flexed and extended. The operation was prepared with the leg adducted. The surgical procedures are as follows: (1) an approximately 10-cm skin incision was made along the ITB centered at the tip of the greater trochanter and the dissection continued to sufficiently expose the anterior and posterior aspects of the ITB and insertion of the gluteus maximus; the site of snapping sound is determined while the hip is flexed and extended; (2) Prior to N-plasty, the anterior and posterior margins are marked

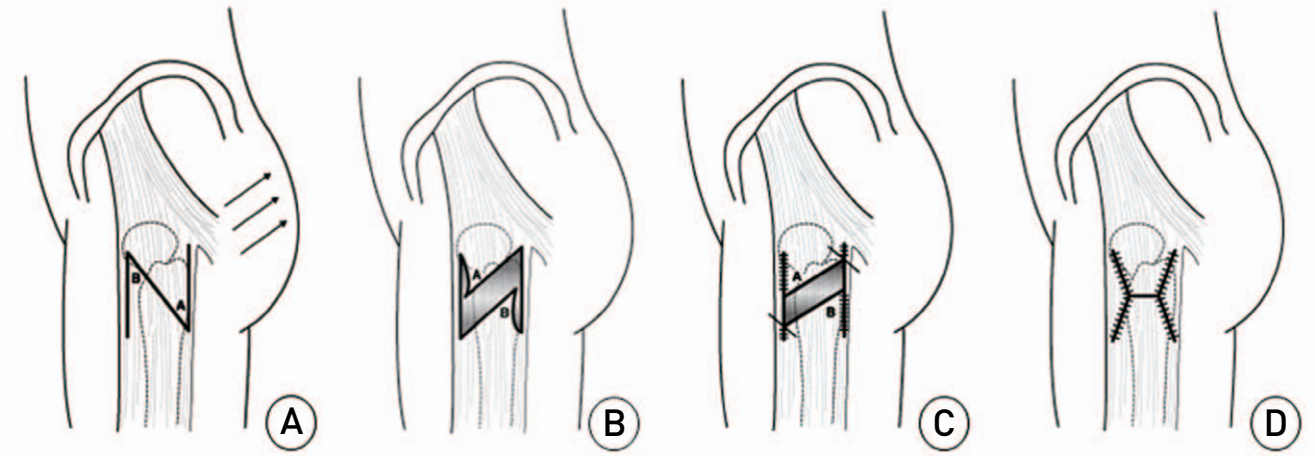

Fig. 2. Diagram of N-plasty design by Yi et al.[1] shows incision and transposition of iliotibial band. (**A**) Proximal flap and distal flap are determined. (**B**) Proximal flap is sutured cross with distal flap. (**C**) Suture is performed at each incision edge. (**D**) Iliotibial band could be lengthened and narrowed.

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using surgical site-marking ink by leaving 7-10 mm of the anterior and posterior aspects of the ITB; (3) A vertical line was drawn in the anterior and posterior margins and marked at the tip of the greater trochanter; (4) The spot meeting at the posterior margin was marked by drawing extension lines from anterior margin to proximal and distal portion of posterior margin with 30˚ of angle each using a protractor. The lines marked from upper and lower posterior margin to the anterior margin are the length of the posterior margin before N-plasty. To measure the length of extended lines, the mid-points of the extended lines up and down the anterior and posterior margins were marked using sutures; (5) When the lengths of the anterior and posterior margins are determined, the line drawn transversely from the upper end of the anterior margin to the lower end of the posterior margin and vertically to the fibers of the gluteus maximus muscle was initially incised and the thickness of resection margin is measured; (6) A second incision was made at the marked anterior and posterior margins of the ITB. An N-shaped incision line was made on the left side and the mirror image of N on the right side. When thickened bursas were present, incision was performed. By intraoperatively determining the degree of tightness at the anterior or posterior margin in the ITB using hands, additional incisions were made to relieve remaining tightness in the ITB; (7) Incised flaps at the proximal and distal portions are placed across each other. Sutures were used at each incision edge using absorbable sutures so the ITB could be lengthened and narrowed (Fig. 2); and (8) A clicking sensation with the hip flexed and extended was resolved, and elongated length of the ITB after N-plasty was confirmed by measuring the length of suture marked in advance (Fig. 3).

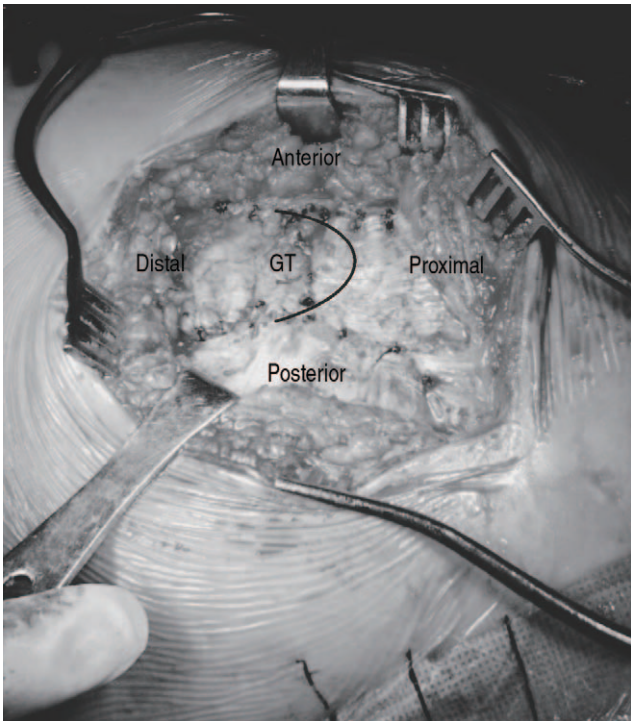

Fig. 3. Clinical photograph shows the figure of N-plasty on the iliotibial band.
GT: greater trochanter.

4. Postoperative Management

Patients were put on bed rest with the hip abducted and externally rotated for pain relief and stabilization of the surgical site for the first two postoperative weeks. Weight bearing was restricted and ambulation using crutches was recommended. Partial weight bearing was started using crutches from the 2nd postoperative week. A continuous passive motion device was used for the first postoperative month to prevent soft tissue adhesion around the trochanteric area. Q-exercise was gradually increased in intensity for the first 6 postoperative weeks regardless of operation time, and the subjects were allowed to begin full weight bearing and return to daily activities from the 6th postoperative week.

RESULTS

All patients complained of a snapping sound associated with pain during hip movement and had problems in performing daily activities such as walking, running or climbing. Popping sounds diminished or disappeared during hip movement with the leg in an externally rotated position. In all patients, the results of Ober's test were negative and there was no history of trauma, surgery or childhood hip problems in any patients. X-ray findings were also normal in all cases. This syndrome was differentiated from other diseases based on preoperative MRI findings. Thickening of the posterior aspect of the ITB and the anterior border of the gluteus maximus was observed. Preoperative tenderness over the greater trochanter was observed in 19 cases. Since thickening of the greater trochanteric bursa was identified intraoperatively in all cases, trochanteric bursectomy was conducted. N-plasty yielded a successful outcome in all 24 cases. Of these, 20 cases had an extra incision along the bilaterally incised margins of ITB after the ITB incision vertically downward through the fibers of gluteus maximus during N-plasty to relieve ITB tightness.

VAS scores decreased from 6.77 (range, 6-9) preoperatively

to 0.09 (range, 0-2) postoperatively (P<0.001), and mHHS improved from 69.5 (range, 44-82.5) to 97.8 (range, 92.4-100) after surgery (P<0.001). Surgical site infection occurred as a postoperative complication in one case in which a culture test was positive for methicillin-resistant *Staphylococcus aureus*. After administration of vancomycin for two weeks, the condition improved without any further relapses. The mean length of the thickened posterior border of ITB was 7.2 mm (range, 5-16 mm). The mean length of the ITB elongated in the longitudinal direction was 26.4 mm (range, 20-40 mm) (Table 1). There were no relapses, limitations in daily routine activities, abnormal gait or weakness of the abductor muscles in the follow-ups.

DISCUSSION

The most common causes for snapping hip are intra- and extra-articular in origin, and extra-articular snapping is further subdivided into external and internal forms. The most common causes of external snapping hips are a thickened ITB as it passes over the greater trochanter[7], fibrosis of the posterior fibers of the gluteus maximus[8], congenital or developmental tightness of the gluteus maximus[9], dysplasia at myotendinous junction of the gluteus maximus[10], a venous hemangioma of the gluteus maximus[11], osteochondroma in the greater trochanter[12], lateral transition of the great trochanter after total hip arthroplasty with the use of longer neck[13] and others. Larsen and Johasen[5] suggested that the presence of a small femoral-neck angle may contribute to snapping hip by accompanying coxa vara. On the contrary, Yi et al.[1,3] reported that no signifcant differences were found in a comparative study using experimental and control groups. Among the various causes of snapping hip, the most common is a thickened ITB. There are different opinions regarding pain in relation to snapping hip. Zoltan et al.[6] and Allen and Cope[2] suggested that pain is associated with greater trochanteric bursitis and snapping hip originates from friction between tight ITB and the greater trochanter in certain positions. However, Larsen and Johasen[5] detected no greater trochanteric bursitis in many cases that underwent surgery. Yi et al.[3] addressed that even though thickening of the bursa was found in all patients, this condition was not a direct cause of pain. In this study, all patients had greater trochanteric bursitis, but they did not complain of pressure pain in the greater trochanter upon preoperative physical exam. Since pressure pain and pain during exercise were present in the thickened posterior aspect of the ITB and the anterior gluteus maximus, snapping hip seems to be associated with pain originating from the muscles or tendons.

Snapping hip can be treated conservatively or surgically. Asymptomatic snapping hip resolves spontaneously, but when accompanied with pain typically resolves with conservative treatment. Conservative treatments include restriction of physical activity, stretching exercise, anti-inflammatory drugs, physical therapy, local steroid injection, botox injection and others[2,5]. When conservative treatment fails, surgical options can be considered. The most appropriate time for surgical treatment still remains controversial because the duration of conservative treatment varies by study. Considering the nature of patients' occupation, patients were included as subjects for surgical treatment when severe pain and discomfort persisted in daily routines despite conservative treatment including stable medical therapy, restriction of physical activity, oral anti-inflammatory and muscle relaxants, stretching and physical therapy excluding intramuscular injection for more than 3 months.

Several surgical treatments for external snapping hip have been introduced. A wide range of surgical techniques have been described (e.g., cruciate incision by Brooker[14] in 1979, partial excision of an ellipsoid-shaped segment of the ITB by Zoltan et al.[6] in 1986, excision and suture by Larsen and Johansen[5] in 1986, cruciate incision by Féry and Sommelet[15] in 1988, Z-plasty by Brignall and Stainsby[4] in 1991, step-cut lengthening by White et al.[16] in 2004, endoscopic ITB release by Ilizaliturri et al.[17] in 2006, N-plasty by Yi et al.[1] in 2008, modified Z-plasty by Nam et al.[9] in 2011). In 2012, Yi et al.[3] performed N-plasty in 37 cases (32 patients) with external snapping hip and reported success in 33 cases (89.2%) and failure in 4 cases. Reoperation was done in 3 of 4 failed cases. No recurrence occurred after performing lengthening incision. Conservative treatment was used in one case. The authors of this study applied Yi et al.'s[1,3] N-plasty approach resulting in low relapse rates among large sample sizes. Incision design was inconsistent in the initial stage of N-plasty, and the suture shape became similar to the suture site of Z-plasty as transverse incisions were extended. To maximize the effect of N-plasty and prevent becoming the Z-plasty, the lengths of the anterior and posterior margins and the lengths of incised anterior and posterior margins should be exactly the same. To match the lengths of incised anterior and posterior margins to the lengths of crossed anterior and posterior margins, the transpositioned anterior and posterior margins should be placed in the middle of the anterior and posterior margins to be sutured. In our N-plasty design, the triangle becomes equilateral as the angle formed by two sides of a triangle is measured 60˚ (Fig. 4).

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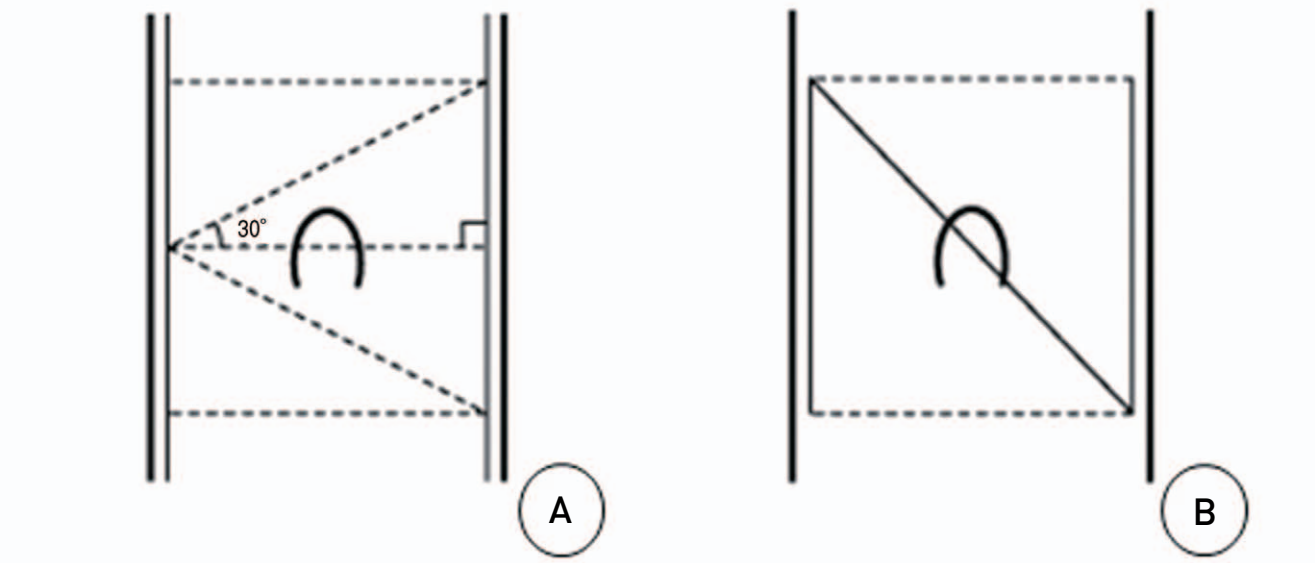

Fig. 4. (**A**) Anterior and posterior margin lengths are determined by drawing lines from the anterior margin at the area of greater trochanter to proximal and distal portion of posterior margin with 30° of angle each. (**B**) Design of the N-plasty is accomplished by determined length of the anterior and posterior margin.

This is the reason why the angle has been extended to 30° in the surgical procedure no. (4). In this way, the ITB can be narrowed to the maximum extent as the four sides of H-shape are all of the same length. If the incised lengths and the crossed lengths to be sutured differ, the design consequently becomes similar to the shape of Z-plasty.

In all operations, before suturing incised flaps of the ITB crossed each other, the degree of tightness in the ITB was determined and additional incisions were conducted to relieve remaining ITB tightness and to prevent postoperative relapse. Using the above N-plasty design, we were able to elongate the length of ITB by 26.4 mm (range, 20-40 mm) on average. Pain and snapping sound were resolved in all cases. At the final follow-up, satisfactory results were achieved in terms of relapse and daily activities without discomfort.

This retrospective study was limited in certain aspects. Since the present study used a single surgical technique, surgical results and the degree of improvement in clinical symptoms could not be compared to those of other surgical techniques. Moreover, this study was limited by the relatively small sample size of only young male soldiers. No study results have been obtained from female or older patients. Because of the relatively short follow-up period, further investigation by meta-analysis with long-term follow-up studies is warranted for more objective analysis.

CONCLUSION

Modified N-plasty appears to be an effective and satisfactory treatment option for external snapping hip recalcitrant to conservative management with ITBs by relieving ITB tightness and lengthening the ITB thus preserving ITB form and function.

CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

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