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ORIGINAL ARTICLE

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Evaluation of the results of flexor hallucis longus tendon transfer for chronic Achilles tendinopathy

Avaliação dos resultados da transferência do tendão flexor longo do hálux na tendinopatia crônica de Aquiles

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ABSTRACT

Objective: To demonstrate that transfer of the flexor hallucis longus (FHL) through a single access site for Achilles tendinosis provides good results and can allow satisfactory recovery of ankle flexion strength.

Methods: This is a case-control study with 28 consecutive patients who underwent surgery for Achilles tendon debridement and FHL transfer between January 2009 and July 2015. The patients' body mass index (BMI), plantar flexion strength and ankle dorsiflexion strength were assessed using an isokinetic dynamometer (Humac Norm model, CSMi) and the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale.

Results: Of the 28 patients, 53.8% were women, and the mean age was 55 years. After a median follow-up of 3.1 years, the plantar flexion strength of the operated ankles was 26.42 Nm (± 2.18), and the dorsiflexion strength was 16 Nm (± 1.99). The final AOFAS score was 85.3 points, with 82.1% of patients achieving good and excellent results. The results showed a significant difference in plantar flexion strength (p=0.0001) between the operated foot and the contralateral foot. No significant difference was found when comparing patients with different BMIs in relation to muscle strength and AOFAS score.

Conclusion: FHL transfer surgery using a single posteromedial route for chronic Achilles tendinopathy presents good functional results and is a safe technique with a low complication rate.

Level of Evidence III; Therapeutic Studies; Case Control Study.

Keywords: Achilles tendon; Tendon transfer; Tendinopathy.

RESUMO

Objetivo: Demonstrar que a transferência do flexor longo do hálux (FLH) na tendinose do Aquiles, através de acesso único tem bons resultados e é capaz de oferecer bom nível de recuperação da força de flexão plantar do tornozelo.

Métodos: Este é um estudo de caso-controle com 28 pacientes consecutivos, que foram submetidos à cirurgia de desbridamento do tendão de Aquiles e transferência do FLH, entre janeiro de 2009 e julho de 2015. Os pacientes foram avaliados quanto aos seus índices de massa corporal (IMC), a força de flexão plantar e dorsiflexão do tornozelo, através de dinamômetro isocinético (CSMI, modelo HUMAC NORM), e a escala AOFAS para retropé e tornozelo.

Resultados: Dos 28 pacientes, 53,8% eram mulheres, e a média de idade foi de 55 anos. Após um acompanhamento médio de 3,1 anos, a força de flexão plantar dos tornozelos operados foi de 26,42 N.m (+ - 2,18) e 16 N.m (+ -1,99) de flexão dorsal. O escore AOFAS final foi de 85.3 pontos, totalizando 82,1% de bons e excelentes resultados. Os resultados mostraram diferença significativa ao comparar a força de flexão plantar (p=0,0001) entre o pé operado e o pé contralateral. Não houve diferença estatisticamente significativa ao comparar pacientes com diferentes IMC em relação à força muscular e o escore AOFAS.

Conclusão: A cirurgia de transferência do FLH por única via posteromedial nas tendinopatias crônicas do Aquiles apresenta bom resultado funcional, além de ser uma técnica segura e com baixo índice de complicações.

Nível de Evidência III; Estudos Terapêuticos; Estudo de Caso-Controle.

Descritores: Tendão do calcâneo; Transferência tendinosa; Tendinopatia.

Work performed at the Instituto Nacional de Traumatologia e Ortopedia, Rio de Janeiro, RJ, Brazil.

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INTRODUCTION

Achilles tendinopathy is a common pathology that can be caused by insertional enthesopathy or a chronic tendon tear. Patients often experience persistent pain in the posterior region of the heel, usually at the beginning and end of exercise, which may become disabling, particularly in runners[1-5].

Conservative treatment for chronic Achilles tendon degeneration involves nonsteroidal anti-inflammatory drugs (NSAIDs), immobilization with orthosis, stretching exercises, injection therapies and extracorporeal shock wave therapy (ESWT), which usually provide good results[1,4,5]. However, the outcomes of such treatments can be unpredictable when a patient has an advanced degree of injury and tendinosis[4,5].

Several surgical procedures have been proposed for Achilles tendonopathy, such as tendon debridement combined with retrocalcaneal bursectomy and resection of the posterior angle of the calcaneus[4-6]. However, when more than 50% of the tendon is compromised in patients over 50 years old and for injuries with gaps larger than 5cm, tendon transfer is recommended[2,7-9]. Some authors have advocated the use of the flexor hallucis longus (FHL) tendon because it is the strongest plantar flexor of the ankle after the Achilles tendon, exhibits phasic activity, and has a collinear axis with the Achilles tendon[7,9]. In addition, the distal muscle belly of the FHL can ensure better vascularization of the degenerated Achilles tendon[10,11].

Although various surgical techniques provide good results, some patients have unfavorable outcomes regardless of the strategy used due to uncertain factors, such as obesity[4,5,12,13]. The aim of this study is to demonstrate that transfer of the flexor hallucis longus tendon through a single access point to treat Achilles tendinosis provides good results and can allow satisfactory recovery of ankle flexion strength. Furthermore, we evaluate the impact of body weight on the final outcome.

METHODS

This study was approved by the Research Ethics Committee with registration in the Brazil Platform under CAAE number: 51763615.6.0000.5273.

In this retrospective study, we evaluated the results of FHL tendon transfer through a single access point for the treatment of Achilles tendinosis.

A total of 28 patients with insertional enthesopathy or chronic Achilles tendon rupture who underwent surgery at our institution between January 2009 and July 2015 and were followed-up for at least one year after surgery were included in the study. The diagnosis of chronic Achilles tendinosis was determined based on clinical and radiographic evaluations. All patients had preoperative radiographs showing intratendinous calcification or calcification of the Achilles tendon insertion. Candidates for the procedure were selected after conservative treatment failed, including at least three months of Achilles tendon-specific physical therapy, analgesic and anti-inflammatory medications, and stretching and eccentric strengthening of the triceps sural muscle.

The exclusion criteria were treatment using other transfer techniques (use of other tendons or FHL transfer using two access sites), bilateral injury, previous surgery in the tendon, and gait changes due to other diseases, neurological diseases, or decreased strength in the lower limbs.

All selected patients signed an informed consent form and agreed to participate in the study. Each patient's body mass index (BMI), muscle strength and overall ankle function were assessed using the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale[14]. The study met all the requirements regarding studies involving humans.

Surgical technique

All patients underwent surgery using the same technique, which was previously described by DeCarbo[11]. The patients were placed in the prone position with a cushion under the contralateral hip and a pneumatic cuff on the proximal region of the operative thigh. A posteromedial longitudinal incision of approximately 8-10cm was made along the Achilles tendon. Then, the tendon was examined visually; when more than 50% of its fibers were compromised, the entire tendon was resected from its insertion to the most distal region possible where the tendon presented good quality. Patients who did not present degeneration of more than half of the fibers were excluded from the study. Along with the tendon, all synovial and inflammatory

peritendinous tissues and the retrocalcaneal bursitis were resected. When present, ostectomy of the Haglund tuberosity was performed. A guide wire with a suture passer was introduced into the calcaneus, and a tunnel was created with a 7-mm-diameter drill. Then, a deeper dissection was performed through the deep rear leg fascia to identify the muscle belly and FHL tendon. The ankle and hallux were flexed simultaneously, allowing proximal retraction of the FHL tendon to cut it as distally as possible with a number 15 scalpel blade in the medial wall of the calcaneus in the tarsal tunnel. The FHL tendon was repaired with a Krackow suture using Vicryl thread and then transferred to the calcaneus using the guide wire with the suture passer. The tendon was fixed to the calcaneus with a 7-mm-diameter bioabsorbable interference screw with the foot in plantar flexion at approximately 15 to 20º. Lastly, the remaining Achilles tendon was sutured to the FHL tendon using single stitches to maintain the strength of the gastrocnemius-soleus complex (Figure 1).

Within 24 hours, the patients were discharged from the hospital after a dressing change, control radiograph acquisition and plaster cast application. The patients remained in gravitational equinus without weight-bearing for four weeks, followed by four weeks with a plaster cast in a neutral position with weight-bearing. Then, the immobilizer was removed, and physical therapy was initiated for gait training and proprioception for a period of six weeks. After the immobilizer was removed, the patients were instructed to wear elastic stockings and sneakers during the physical therapy rehabilitation period.

Strength analysis

The strength of the muscles involved in plantar flexion was quantified using an isokinetic dynamometer (HUMAC NORM model, CSMi) and comparing the operated leg and the contralateral (healthy) leg.

Two Velcro strips intersecting across the back of the foot were tied to the device platform. The knee on the dominant side was positioned between 100 and 110º of flexion and the opposite leg was placed parallel to the foot support. A padded block, thigh stabilizer and Velcro strap secured the distal portion of the thigh on the tested side, and a belt around the abdomen and chest secured the torso. The test consisted of five maximal repetitions of plantar flexion movements and ankle dorsiflexion performed at an angular velocity of 60º/s in concentric mode. Muscle strength was measured during the movements tested, with the highest value characterized as the peak torque and used for the subsequent analyses.

Data analysis

The clinical data obtained with the collection instrument and the strength values were tabulated in a Microsoft spreadsheet. A descriptive analysis of the study variables and their associations based on Pearson correlation coefficients was conducted. Grubbs's test was used to verify the presence of extreme results. The 95% confidence interval (95% CI) was calculated and results with a p value less than 5% ($p<0.05$) were considered statistically significant.

RESULTS

Of the 28 patients enrolled, 13 were men and 15 were women, with a mean age of 55 years (31-75 years) and a mean follow-up of 3.1 years (1.2-6.3 years). Five patients had a chronic Achilles injury, and 23 had insertional tendinopathy. Regarding complications, five cases of suture dehiscence were noted, which were resolved with serial dressings and did not require further surgical intervention. No cases of re-rupture, thrombosis, neurological lesions, hallux deformities or infection were noted.

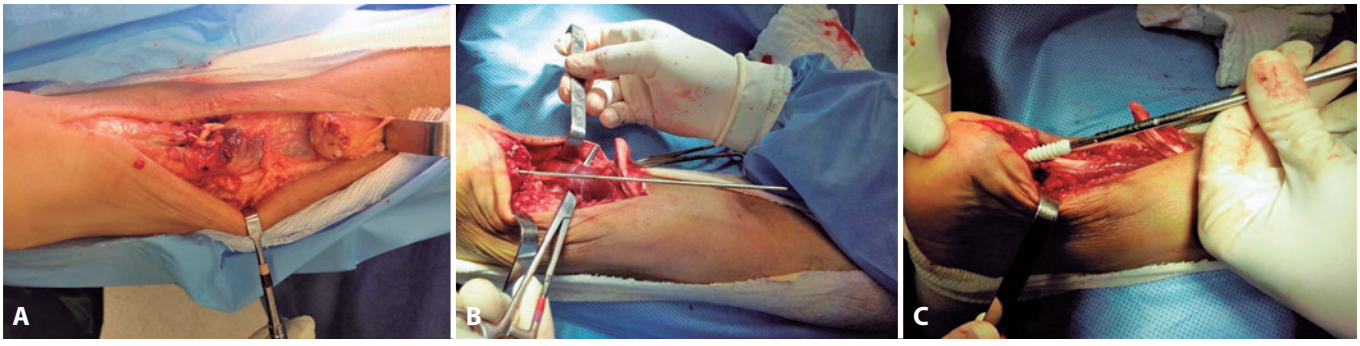

Figure 1. FHL tendon transfer surgical technique through a single posteromedial access site.
Source: Author's personal archive.

In the strength assessment of the lower limbs, a mean value of 26.42±2.18 Nm was found for plantar flexion of the injured ankles, whereas the mean value observed in the normal ankles was 36.9±3.19 Nm (Figure 2). The mean dorsiflexion strength was 16±1.99 Nm in the operated ankles and 15.5±1.09 Nm in the contralateral ankles (Figure 3). Thus, no difference in dorsiflexion strength was observed between the ankles (p=0.7), whereas a significant difference was found for plantar flexion strength (p=0.0001) (Table 1). Table 2 and Figure 4 show the plantar flexion strength relationship between the injured and normal limbs in men and women.

The mean AOFAS score was 85.3 points, ranging from 66 to 100 points. Overall, 82.1% of the patients exhibited good and excellent results (75-100 points), 17.9% achieved moderate results (60-74 points), and no patient was considered to have a poor result.

When assessing the association between BMI and the degree of recovery (the AOFAS score), a higher BMI was found to correspond to a lower degree of recovery, but the association was not significant (Figure 5).

By analyzing the associations between patients with BMIs of 20-24.5kg/m^2 and 40-44.9kg/m^2 and the degrees of plantar flexion and dorsiflexion of the ankle, a higher BMI was found to correspond to greater difficulty in correctly performing dorsiflexion or plantar flexion; however, for both correlations, the differences were not significant (p=0.1) (Figure 6).

Finally, by analyzing the degree of dorsiflexion of the injured ankles compared with that of the normal ankles in patients in the same BMI category, we found a difference with a value of p=0.4. Furthermore, for plantar flexion of

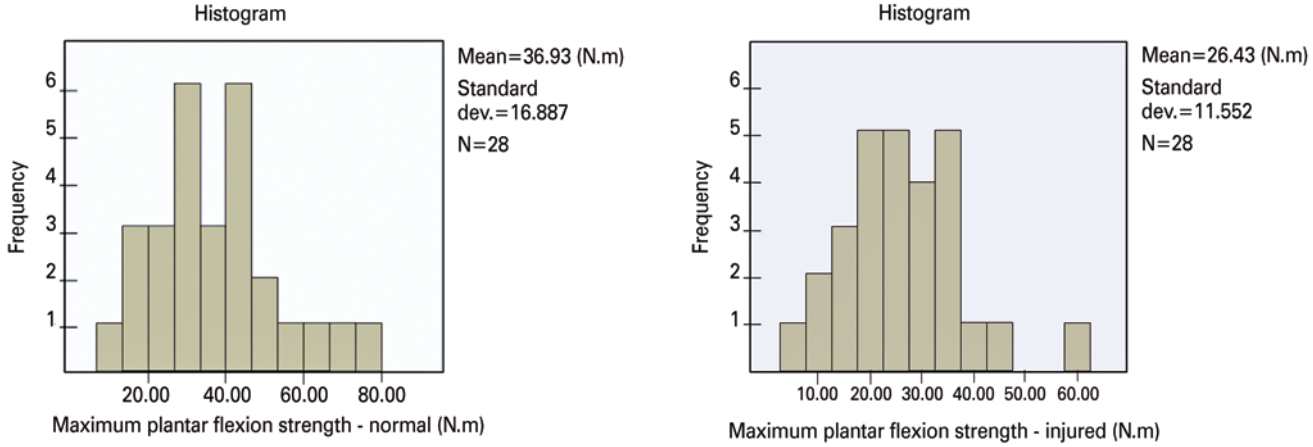

Figure 2. Histogram of plantar flexion of a normal ankle and an injured ankle (N=28).
Source: Prepared by the author based on the results of the study.

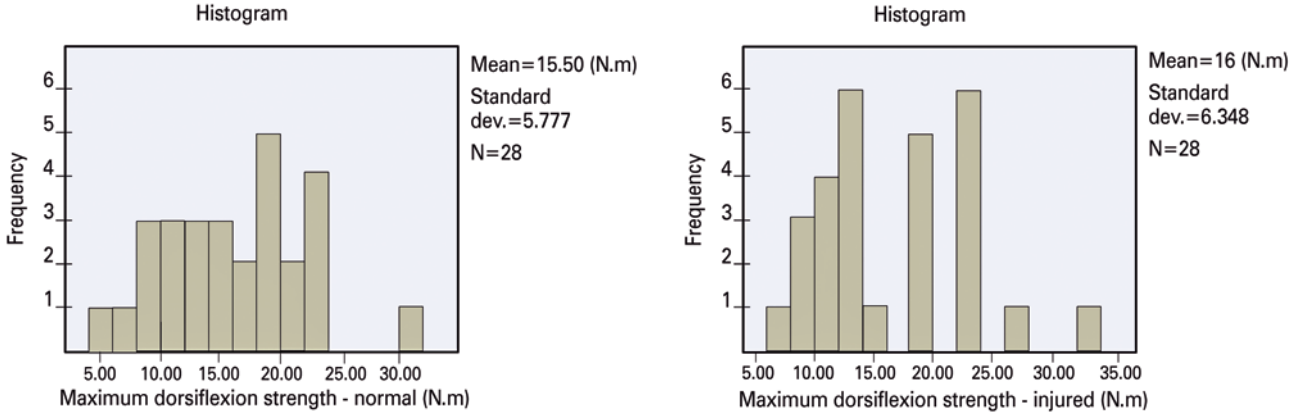

Figure 3. Dorsiflexion histogram of a normal ankle and an injured ankle (N=28).
Source: Prepared by the author based on the results of the research.

Table 1. Paired sample tests

		df	p value (2-tailed)
Pair 1	Torque max PF (inj) – torque max PF (norm)	27	0.000
Pair 2	Torque max DF (inj) – torque max DF (norm)	27	0.525

max=maximum; PF=plantar flexion; inj=injured; norm=normal; DF=dorsiflexion.
Source: Prepared by the author based on the results of the study.

Table 2. Plantar flexion dependent variable

1=W 2=M 1=injured 2=normal		Mean	SD	N
1.00	1.00	24.0714	8.27846	14
	2.00	31.4286	9.89727	14
	Total	27.7500	9.70538	28
2.00	1.00	28.7857	14.02294	14
	2.00	42.4285	20.71682	14
	Total	35.6071	18.69708	28
TOTAL	1.00	26.4286	11.55159	28
	2.00	36.9286	16.88727	28
	Total	31.6786	15.28292	56

Source: Prepared by the author based on the results of the study.

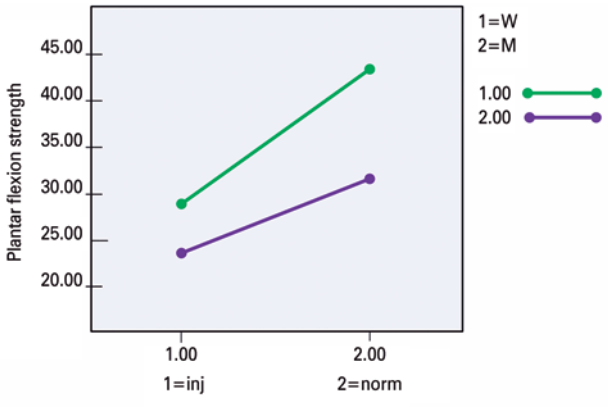

Figure 4. Plantar flexion of injured (inj) and normal (norm) ankles by gender.
Source: Prepared by the author based on the results of the study.

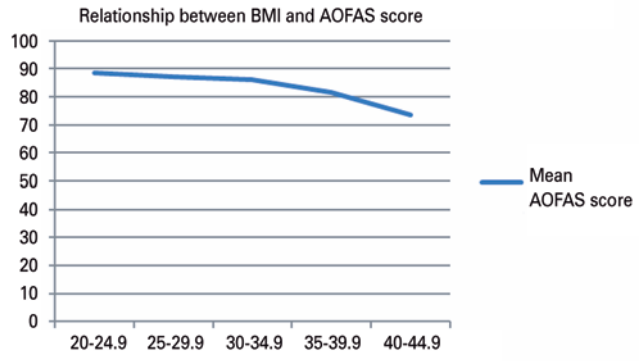

Figure 5. Degree of recovery X BMI.
Source: Prepared by the author based on the results of the study.

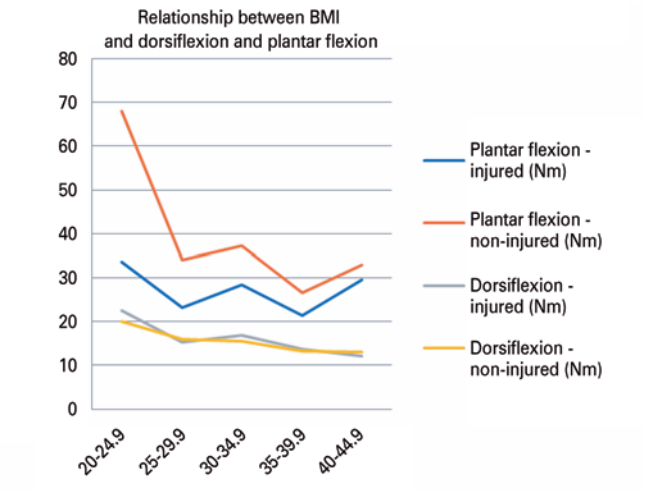

Figure 6. Plantar flexion X dorsiflexion (injured and normal ankles) strength in relation to BMI.
Source: Prepared by the author based on the results of the study.

the injured ankles compared to that of the normal ankles, in all BMI categories, the p value was 0.1.

DISCUSSION

In our study, we evaluated 28 patients with chronic Achilles tendinopathy who underwent FHL tendon transfer and resection of the entire injured tendon through a single posteromedial access site. The mean AOFAS was 85.3 after a mean follow-up of 37 months. In addition, 82.1% of the patients had good or excellent results.

Good results with this surgery have been reported in the literature, with AOFAS scores ranging from 86 to 98.3 points[11,15-20]. However, although our results are very close to those of other studies, some studies had considerably varied samples in relation to the surgical technique used. In the study of Schon et al.[21], the site for removal of the FHL graft was determined by the surgeon, with some cases involving a single posteromedial route and others involving a plantar accessory route. In another study[15], some patients underwent FHL transfer performed through a transosseous tunnel in the calcaneus, while others were treated using a transtendinous technique. Moreover, El-Tantawy et al.[3] reported a final AOFAS score of 98.3 points in a study with 13 patients and a mean follow-up of 24.5 months.

The significant difference (p=0.0001) in plantar flexion strength observed between the operated ankle and the contralateral ankle substantiates the decrease in strength on the injured side. However, several studies have noted that such loss of strength does not reflect a real limitation

and a decrease in quality of life[17,20]. Wapner et al.[22] observed losses of plantar flexion strength and torque of 29.5% and 41.8%, respectively. Wilcox et al.[20] reported a mean reduction of 33% in plantar flexion strength and a final AOFAS score of 86 points. Martin et al.[17] showed torque losses of 22.8% (30º/sec) and 30.4% (60º/sec), reflecting significant decreases compared to healthy contralateral ankles. These authors concluded that despite the significant loss of strength, functional status did not seem to be affected, with no difference between the final Short Form (SF)-36 scores of their patients and those of the general U.S. population. Another study[9], which obtained an AOFAS score of 96.4 points, reported that less than 50% of the study patients were able to elevate the operated ankle with one-foot support, but they argued that this inability does not seem to affect daily activities, possibly because over time, FHL hypertrophy occurs as a form of adaptation and compensation when the function of the gastrocnemius--soleus complex is severely compromised. Confirming this hypothesis, Oksanen et al.[23] evaluated operated ankles using magnetic resonance imaging and showed an average increase of 52% in the diameter of the FHL muscle belly relative to that measured in the immediate postoperative period.

When comparing the patients with BMIs of 20-24.5kg/m^2 and 40-44.9kg/m^2 with respect to strength, we found that the patients with a higher BMI exhibited greater difficulty in performing both plantar flexion and dorsiflexion of the ankle; however, the relationship between BMI and the AOFAS score was not statistically significant. Contrary to our expectations prior to the study, these findings support the use of the described technique in patients with high BMIs based on results similar to those of leaner patients.

The limitations of our study include its retrospective design and a low number of patients, but it is comparable with most studies in the literature[3,9,10,17,19]. In addition, the study participants had two distinct etiologies of injury, including insertional enthesopathy and chronic rupture of the calcaneal tendon. The strengths of the study include the use of the same surgical technique and the same postoperative protocol for all patients. All patients were evaluated by an examiner who was not the primary surgeon in any of the cases. The objective evaluation of postoperative strength using an isokinetic dynamometer and the use of each patients' healthy contralateral limb as the control condition contributed to the reliability and reproducibility of the results.

CONCLUSION

Resection of the entire injured tendon combined with FHL tendon transfer through a single posteromedial access site for the treatment of chronic Achilles tendinopathy provides a good functional result and is a safe technique with a low complication rate. Patients with high BMIs also show good functional results.

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REFERENCES

1. Scott A, Huisman E, Khan K. Conservative treatment of chronic Achilles tendinopathy. CMAJ. 2011;183(10):1159-65.
2. Elias I, Raikin SM, Besser MP, Nazarian LN. Outcomes of chronic insertional Achilles tendinosis using FHL autograft through single incision. Foot Ankle Int. 2009;30(3):197-204.
3. El-Tantawy A, Azzam W. Flexor hallucis longus tendon transfer in the reconstruction of extensive insertional Achilles tendinopathy in elderly: an improved technique. Eur J Orthop Surg Traumatol. 2015 Apr;25(3):583-90.
4. Wiegerinck JI, Kerkhoffs GM, van Sterkenburg MN, Sierevelt IN, van Dijk CN. Treatment for insertional Achilles tendinopathy: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2013;21(6):1345-55.
5. Roche AJ, Calder JD. Achilles tendinopathy: A review of the current concepts of treatment. Bone Joint J. 2013;95(10):1299-307.
6. Pfeffer G, Gonzalez T, Zapf M, Nelson TJ, Metzger MF. Achilles Pullout Strength After Open Calcaneoplasty for Haglund's Syndrome. Foot Ankle Int. 2018;39(8):966-969.
7. de Cesar Netto C, Chinanuvathana A, Fonseca LFD, Dein EJ, Tan EW, Schon LC. Outcomes of flexor digitorum longus (FDL) tendon transfer in the treatment of Achilles tendon disorders. Foot Ankle Surg. 2017 Dec 19.
8. Lin JL. Tendon transfers for Achilles reconstruction Foot Ankle Clin. 2009;14(4):729-44.
9. Will RE, Galey SM. Outcome of single incision flexor hallucis longus transfer for chronic achilles tendinopathy. Foot Ankle Int. 2009; 30(4):315-7.
10. Hahn F, Meyer P, Maiwald C, Zanetti M, Vienne P. Treatment of chronic achilles tendinopathy and ruptures with flexor hallucis tendon transfer: clinical outcome and MRI findings. Foot Ankle Int. 2008;29(8):794-802.
11. DeCarbo WT, Hyer CF. Interference screw fixation for flexor hallucis longus tendon transfer for chronic Achilles tendonopathy. J Foot Ankle Surg. 2008;47(1):69-72
12. Burrus MT, Werner BC, Park JS, Perumal V, Cooper MT. Achilles Tendon Repair in Obese Patients Is Associated With Increased Complication Rates. Foot Ankle Spec. 2016;9(3):208-14.
13. Neufeld SK, Farber DC. Tendon transfers in the treatment of Achilles' tendon disorders. Foot Ankle Clin. 2014;19(1):73-86.
14. Rodrigues RC, Masiero D, Mizusai JM, Imoto AM, Peccin MS. Cohen M. et al. Tradução, adaptação cultural e validação do American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale. Acta Ortop Bras. 2008;16(2): 107-11.
15. Rahm S, Spross C, Gerber F, Farshad M, Buck FM, Espinosa N. Operative treatment of chronic irreparable Achilles tendon ruptures with large flexor hallucis longus tendon transfers. Foot Ankle Int. 2013;34(8):1100-10.
16. Hunt KJ, Cohen BE, Davis WH, Anderson RB, Jones CP. Surgical treatment of insertional Achilles tendinopathy with or without flexor hallucis longus tendon transfer: a prospective, randomized study. Foot Ankle Int. 2015;36(9):998-1005.
17. Martin RL, Manning CM, Carcia CR, Conti SF. An outcome study of chronic Achilles tendinosis after excision of the Achilles tendon and flexor hallucis longus tendon transfer. Foot Ankle Int. 2005; 26(9):691-7.
18. Den Hartog BD. Flexor hallucis longus transfer for chronic Achilles tendonosis. Foot Ankle Int. 2003;24(3):233-7.
19. Monroe MT, Dixon DJ, Beals TC, Pomeroy G, Crowley DL, Manoli A. Plantarflexion torque following reconstruction of Achilles tendinosis or rupture with flexor hallucis longus augmentation. Foot Ankle Int. 2000;21(4):324-9.
20. Wilcox DK, Bohay DR, Anderson JG. Treatment of chronic achilles tendon disorders with flexor hallucis longus tendon transfer/ augmentation. Foot Ankle Int. 2000;21(12):1004-10.
21. Schon LC, Shores JL, Faro FD, Vora AM, Camire LM, Guyton GP. Flexor hallucis longus tendon transfer in treatment of Achilles tendinosis. J Bone Joint Surg Am. 2013;95(1):54-60.
22. Wapner KL, Pavlock GS, Hecht PJ, Naselli F, Walther R. Repair of chronic Achilles tendon rupture with flexor hallucis longus tendon transfer. Foot Ankle. 1993;14(8):443-9.
23. Oksanen MM, Haapasalo HH, Elo PP, Laine HJ. Hypertrophy of the flexor hallucis longus muscle after tendon transfer in patients with chronic Achilles tendon rupture. Foot Ankle Surg. 2014;20(4):253-7.