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The Effect of Trochanteric Epiphysiodesis in Patients Who Underwent Tönnis Triple Innominate Osteotomy for Legg-Calve-Perthes Disease

Legg-Calve-Perthes Hastalığı nedeniyle Tönnis Triple Innominate Osteotomi Yapılan Hastalarda Trokanterik Epifizyodezin Etkisi

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ABSTRACT

Objective: To comparatively evaluate the clinical and radiographic outcomes of performing Tönnis triple innominate osteotomy (TIO) with or without greater trochanteric epiphysiodesis (TE).

Materials and Methods: A total of 37 patients (8 females and 29 males) were enrolled in this retrospective study. Out of them, 14 patients (3 females and 11 males) underwent TE with TIO (TIO+TE group) and 23 patients (5 females and 18 males) underwent TIO only (TIO group). For all patients, the range of motion, leg length discrepancy, and Trendelenburg sign of the affected hips were assessed both preoperatively and at the last control.

Results: At the last control, the mean hip abduction and adduction in the TIO group were significantly higher than those in the TIO+TE group. In terms of Trendelenburg sign and leg length discrepancy, no significant difference was observed between groups. Although the difference in center-trochanteric distance (CTD) between the affected and normal sides was higher in TIO+TE group preoperatively, the difference in articulo-trochanteric distance, CTD, and abductor lever arm length values was the same in the two groups at the latest follow-up.

Conclusion: The results of this study showed that additional TE significantly improved CTD especially in patients who had preoperatively lower CTD values compared to the healthy side.

Keywords: Legg-Calve-Perthes, Tönnis triple innominate osteotomy, trochanteric epiphysiodesis

ÖZ

Amaç: Tönnis üçlü innominat osteotomi (TIO) yapılan hastalarda büyük trokanterik epifizyodez (TE) uygulanan ve uygulanmayan hastaların klinik ve radyografik sonuçlarını karşılaştırmalı olarak değerlendirmektir.

Gereç ve Yöntemler: Bu retrospektif çalışmaya 37 hasta (8 kadın ve 29 erkek) dahil edildi. Bunlardan 14 hastaya (3 kadın ve 11 erkek) TIO ile TE (TIO + TE grubu), 23 hastaya (5 kadın ve 18 erkek) yalnızca TIO (TIO grubu) uygulandı. Tüm hastalarda etkilenen kalçaların hareket açıklığı, bacak uzunluğu farkı ve Trendelenburg işareti hem ameliyat öncesi hem de son kontrolde değerlendirildi.

Bulgular: Son kontrolde, TIO grubundaki ortalama kalça abdüksiyonu ve adduksiyonu, TIO + TE grubundakilerden anlamlı derecede yüksekti. Trendelenburg işareti ve bacak uzunluğu farkı açısından gruplar arasında anlamlı bir fark gözlenmedi. Ameliyat öncesi TIO + TE grubunda etkilenen ve normal taraflar arasındaki merkez-trokanterik mesafe (CTD) farkı daha yüksek olmasına rağmen, son kontrollerinde artikülo-trokanterik mesafe, CTD ve abdüktör kaldıraç kol uzunluğu değerlerindeki fark, iki grupta aynı idi.

Sonuç: Bu çalışmanın sonuçları, özellikle preoperatif olarak daha düşük CTD değerlerine sahip hastalarda sağlıklı tarafa göre ilave TE'nin CTD'yi önemli ölçüde iyileştirdiğini göstermiştir.

Anahtar Kelimeler: Legg-Calve-Perthes, Tönnis üçlü innominat osteotomi, trokanterik epifizyodez

INTRODUCTION

Due to premature fusion of the proximal femoral epiphysis or flattening of the femoral head, greater trochanteric overgrowth may appear in patients with Legg-Calve-Perthes disease (LCPD) (1). For many years, the trochanteric epiphysiodesis (TE) has been performed and

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recommended to prevent trochanteric overgrowth, which can cause the hip abductor lever arm shortening and an abnormal gait in LCPD patients (2, 3).

On the other hand, triple innominate osteotomy (TIO) is considered a successful option as a containment surgery for LCPD, which can be performed in later stages for the elderly without altering proximal femoral anatomy and affecting hip abductor mechanism (4). In the literature, there were limited studies on the effect of TE in combination with pelvic osteotomies for LCPD. Kitoh et al. declared that the main predictor of trochanteric overgrowth was the decreased lateral pillar height in LCPD patients who underwent containment surgery, and the authors recommended a careful follow-up for early prophylactic epiphysiodesis (5).

The current study aimed to evaluate the TE effect in patients who underwent Tönnis TIO for LCPD.

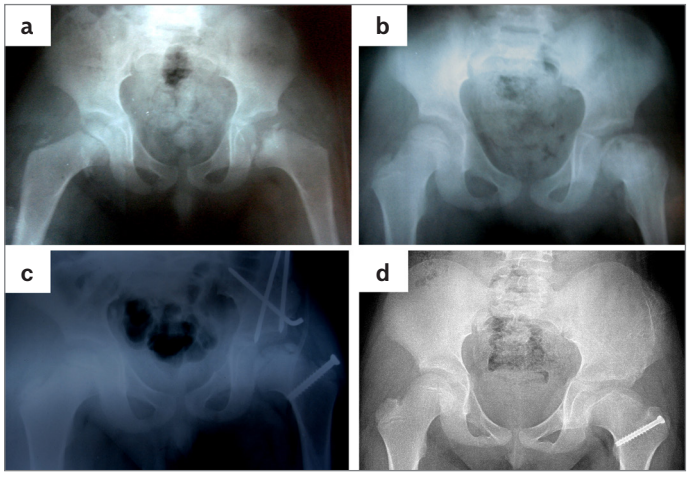

Figure 1. a-d. (a) A 5-year-old boy with the diagnosis of LCPD at the left hip, it was graded as Group C according to Herring's Classification. (b) At 6 years old, insufficient femoral head coverage was detected and operation was planned. (c) Tönnis TIO and TE was performed during reossification stage according to Waldenstrom's Classification. (d) At 12 years old, he had a Stulberg Class III left hip with a minimal trochanteric overgrowth and negative Trendelenburg sign

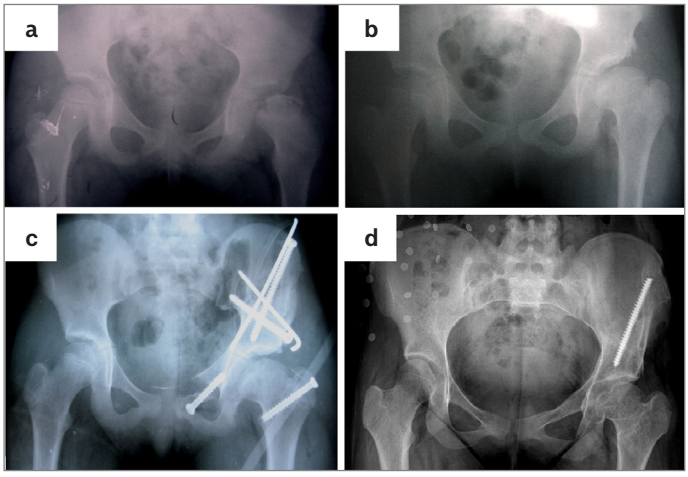

Figure 2. a-d. (a) A 5-year-old girl with the diagnosis of LCPD at the left hip, it was graded as Group C according to Herring's Classification. (b) At 10 years old, insufficient femoral head coverage was detected and operation was planned. (c) Tönnis TIO and TE was performed during remodelling stage according to Waldenstrom's Classification. (d) At 16 years old, she had a Stulberg Class III left hip with trochanteric overgrowth and a positive Trendelenburg sign

MATERIALS and METHODS

This is a retrospective study that was conducted with the approval of the ethical review board of Erzincan University and performed in accordance with the "Declaration of Helsinki." All individual participants who are included in the study provided informed consent. A total of 43 patients underwent Tönnis TIO with the diagnosis of LCPD between 2007 and 2011. The indications for the TIO included femoral head lateralization, insufficient femoral head coverage, and femoral head subluxation. We excluded six patients who had bilateral LCPD from the study to compare the affected side with the normal side. A total of 37 patients (8 females and 29 males) were included in this study. Out of them, 14 patients (3 females and 11 males) underwent TE with TIO (TIO+TE group) and 23 patients (5 females and 18 males) underwent TIO only (TIO group). Metaizeau et al. described a transphyseal screw fixation technique that was used to achieve trochanteric epiphysiodesis (Figures 1 and 2) (6). The patients were called after discharge for control visits at the postoperative 2nd, 6th, 12th, and 24th weeks. Furthermore, all patients were still under follow-up through the annual control visits.

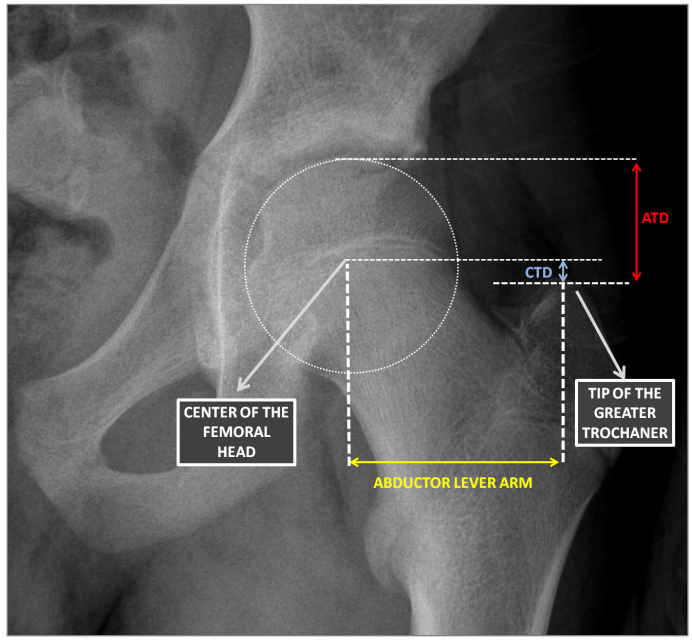

Figure 3. The illustration of the measurements performed on anteroposterior pelvis radiographs. ATD: Articulo-trochanteric distance, CTD: Center-trochanteric distance

Preoperatively and at the last follow-up, the leg length discrepancy and Trendelenburg sign for each patient were assessed. Through pelvis anteroposterior radiographs, radiographic evaluation was performed by one senior surgeon who did not perform the operations. From the preoperative and last follow-up radiographs, center-edge angle (CEA), articulo-trochanteric distance (ATD), center-trochanteric distance (CTD), and horizontal distance between the tip of the trochanter and the center of the femoral head (the abductor lever arm length) were measured (Figure 3). The difference in ATD, CTD, and abductor lever arm length values between the healthy side and the affected side was calculated by subtracting the healthy side from the affected side. We did not prefer to calculate the ratio of the affected side and the healthy side because the negative values were also calculated and this would give false results when we divided the affected side from the healthy side. Moreover, the main disadvantage of calculating the difference in values was that the difference would be increased by the age and length of the children. However, a relatively homogeneous patient population of similar ages was evaluated and the mean age of the patients was also the same at the last follow-up.

Table 1. Patients' demographics and classifications of the disease.

	TIO + TE group (n=14)	TIO group (n=23)	p value
Demographics			
Age at the time of surgery (years)	9 ± 1.7	9.7 ± 2.9	0.212*
Age at the last control (years)	15 ± 2.8	14.2 ± 2.9	0.427*
Gender			0.982**
Female	3 (21%)	5 (22%)	
Male	11 (79%)	18 (78%)	
Classifications			
Waldenstrom's Classification			0.621**
Necrosis	2 (14%)	1 (4%)	
Fragmentation	2 (14%)	4 (17%)	
Reossification	6 (43%)	8 (35%)	
Remodelling	4 (29%)	10 (44%)	
Catterall's Classification			0.255**
Group I	0 (0%)	0 (0%)	
Group II	0 (0%)	1 (4%)	
Group III	0 (0%)	3 (13%)	
Group IV	14 (100%)	19 (83%)	
Herring's Classification			0.915**
Group A	0 (0%)	0 (0%)	
Group B	2 (14%)	3 (13%)	
Group C	12 (86%)	20 (87%)	

TIO: triple innominate osteotomy, TE: trochanteric epiphyseodesis, n: number
* *p value* according to student t-test.
** *p value* according to Pearson Chi-Square test.

We used Waldenström, Catterall, and lateral pillar (Herring) classifications to evaluate the stage of the disease preoperatively and used Stulberg classification to evaluate outcome at the last control [7–10]. Furthermore, we used Harris hip score for the functional evaluation of the patients.

The Statistical Package for Social Sciences version 20.0 (IBM SPSS Corp.; Armonk, NY, USA) was used to perform the statistical analysis. Mean and standard deviation was reported for numeric data, whereas the categorical data were presented as frequency and percent. Mann-Whitney-U test or student *t*-test in accordance with the Shapiro-Wilk normality test was used to perform statistical analysis of the difference in means. Also, Pearson's chi-square test was used to perform a statistical analysis of the difference in frequencies. *P* values lower than 0.05 ($p<0.05$) were considered as statistically significant.

RESULTS

The mean follow-up time of the patients was 5.2±1.2 years. Table 1 shows the patients' demographics and LCPD classifications. Furthermore, no significant difference was observed between groups in terms of demographic data and LCPD classification (Table 1). Also, in terms of Trende-

Table 2. Comparison of preoperative and last control physical examination and Harris hip scores between groups.

	TIO + TE group (n=14)		TIO group (n=23)		p values* (preop comparison of groups)	p values* (last control comparison of groups)
	Preoperative	Last Control	Preoperative	Last Control		
Leg length discrepancy (cm)	0.4 ± 0.6	0.2 ± 0.7	0.5 ± 0.6	0.3 ± 0.5	0.743	0.898
Trendelenburg sign (+ / -)	11 / 3	3 / 11	20 / 3	3 / 20	0.539	0.539
Harris hip score (points)	51.7 ± 8.1	87.3 ± 2.7	54.1 ± 6.6	87.4 ± 2.4	0.375	0.932

TIO: triple innominate osteotomy, TE: trochanteric epiphyseodesis, n: number
* p values according to Mann-Whitney-u test or t-test

Table 3. Comparison of preoperative and last control radiographic measurements between groups.

	TIO + TE group (n=14)		TIO group (n=23)		p values* (preop comparison of groups)	p values* (last control comparison of groups)
	Preoperative	Last Control	Preoperative	Last Control		
Center-edge angle (degrees)	1.7 ± 5.9	27 ± 4.4	(-)0.5 ± 9	23.6 ± 5.4	0.385	0.053
Articulo-trochanteric distance difference(mm)	5.8 ± 4.9	11.8 ± 14.3	3.9 ± 4.5	13.1 ± 8.6	0.265	0.783
Center-trochanteric distance difference (mm)	10.9 ± 6.2	18.6 ± 14	4.3 ± 4.5	16.7 ± 10.3	0.003	0.681
Length of the abductor lever arm differece(mm)	2.2 ± 3.7	5.7 ± 4.2	2.3 ± 4.6	5.8 ± 6.2	0.964	0.943

TIO: triple innominate osteotomy, TE: trochanteric epiphyseodesis, n: number
* p values according to Mann-Whitney-u test or t-test
Bold p values indicate statistical significance

Table 4. Last control Stulberg classification of the patients.

	TIO + TE group (n=14)	TIO group (n=23)
Stulberg classification		
Class I	0 (0%)	1 (4%)
Class II	8 (57%)	12 (52%)
Class III	5 (36%)	8 (35%)
Class IV	1 (7%)	2 (9%)

TIO: triple innominate osteotomy, TE: trochanteric epiphyseodesis, n: number

lenburg sign, leg length discrepancy, and Harris hip scores, no significant difference was observed between groups preoperatively and at the last control (Table 2).

In both groups, CEA improved, and no significant difference was observed between the two groups preoperatively and at the last control. Preoperatively, the difference in CTD from the healthy side was significantly higher in the TIO+TE group than that in the TIO group. However, no significant difference in ATD, CTD, and abductor lever arm length values was observed between the two groups at the last control (Table 3).

Stulberg classifications of the patients at the last control were demonstrated in Table 4. Implant removal at skeletal maturity was performed for all patients. Furthermore, during the follow-up of the patients, no complications were detected.

DISCUSSION

The primary goal of the LCPD treatment is to maintain a spherical femoral head to prevent early degenerative arthritis. Trochanteric overgrowth is considered a secondary problem, leading to abductor weakness and abnormal gait. In the Tönnis TIO technique, the osteotomies of ischium, pubis, and ilium are close enough to the hip joint which allows satisfactory rotation of the acetabulum (11). TIO can be performed for preventing further deformation of the femoral head in the early stages of LCPD and for the containment of the femoral head in the later stages, especially in patients with a sequel of other operations (12).

In the literature, several reports have recommended prophylactic TE to prevent greater trochanteric overgrowth in LCPD patients, especially in those who underwent femoral varus osteotomy (FVO), which may cause abductor weakness and abnormal gait (13–18). Matan et al. compared patients who underwent either FVO or FVO+TE for LCPD and declared that the patients who underwent TE had less abductor weakness, better range of motion, and less pain (13). Joseph et al. recommended early containment treatment with FVO+TE in early ages, which according to their results was found to be superior to conservative management (14). Also, Weiner and Kitakoji et al. recommended TE+FVO due to decreased pitfalls related to FVO alone (15, 16). Recently, Shah et al. reported long-term results of the patients who underwent FVO+TE for LCPD and achieved satisfactory results with a significantly decreased Trendelenburg sign (17). To the best of our knowledge, the disadvantage of proximal FVO is the shortening of the affected limb and abductor moment arm, thus causing abductor weakness and limping after surgery (18). In this study, Tönnis TIO alone or in combination with TE was performed to preserve the abductor mechanism. Preoperatively, there was no significant difference between the two groups in terms of demographics and disease classification. According to our clinical findings, clinical improvements were achieved in both groups compared to the preoperative findings in terms of Trendelenburg sign and Harris hip scores. We were unable to evaluate the decision for performing TE in addition to TIO because of the retrospective design of the study. However, a significant difference in preoperative CTD between groups indicated that patients who underwent additional TE had a significantly higher difference in CTD compared to the healthy side.

On the one hand, McCarthy and Weiner reported that ATD is the indirect measurement of greater trochanteric overgrowth due to the measurement of ATD, which involves the physis of the femoral head affected in LCPD patients (19). Moreover, they found that there was a little change in ATD in the affected hip; however, they concluded that TE might still have an effect in patients aged over 8 years (19). On the other hand, Van Tongel et al. found that there was no difference in ATD when comparing pre- and postoperative values (20). Unlike McCarthy and Weiner, the authors recommended that TE should be performed before the age of eight years (20). Stevens et al. assessed the results of TE in combination with soft tissue release in LCPD patients; they compared pre- and postoperative CTD values and no significant difference was observed (21). Shah et al. compared patients who underwent FVO+TE with the control group and they recommended prophylactic TE and reported that the values of ATD and CTD were significantly greater in the FVO+TE group than those in the controls that were not operated on (17). In our study, we evaluated ATD, CTD, and the abductor lever arm length for two groups preoperatively and at the last control. The difference in ATD, CTD, and abductor lever arm compared to the healthy side was assessed to evaluate patients independently by age. Our radiographic findings showed that additional TE significantly improved CTD especially in patients who had preoperatively lower CTD values compared to the healthy side. As discussed previously, the appropriate time to perform TE for trochanteric overgrowth is still under debate in the literature. We achieved significant clinical and radiographic improvements in the TIO+TE group, which consisted of patients operated on at a mean age of 9 years and preoperatively had a higher difference in CTD compared to the healthy side, and these results supported McCarthy and Weiner. On the other hand, we must keep in mind that we can achieve better outcomes if the TE was performed at earlier ages (Figures 1 and 2). However, in our study, we had no change to determine the appropriate time to perform TE because all TE operations were performed combined with TIO which had different indications for LCPD. However, the results of our study also provide valuable information to orthopedic surgeons about the decision of additional TE during TIO. Based on our study results, when a low CTD was observed preoperatively, additional TE could be considered even for patients aged over 8 years.

Two main limitations were noted for this study. Firstly, the study population was not a large series. However, a larger and homogeneous patient population was comparatively evaluated with respect to previous studies in the literature. Secondly, the criteria for performing TE were not clear, which was also not clearly defined in the literature. However, a preoperatively significant difference in CTD between groups may indicate that patients who underwent additional TE had a significantly higher difference in CTD compared to the healthy side. The main strength of the study was that it is the first study to evaluate the effect of TE in patients who underwent pelvic containment surgery for LCPD. In addition to that, we evaluated a homogenous patient population with similar demographics and disease classification.

In conclusion, based on our findings, patients with lower CTD values benefited from additional TE during Tönnis TIO for LCPD compared to the healthy side. When a low CTD was observed preoperatively, TE should be considered even for patients aged over 8 years.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Erzincan Binali Yıldırım University (33216249-604.01.02-E.37834).

Informed Consent: Informed consent was obtained for each patient.

Peer-review: Externally peer-reviewed.

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Hakem Değerlendirmesi: Dış bağımsız.

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