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ORIGINAL ARTICLE / ARAŞTIRMA YAZISI

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Comparison of Radiological, Functional and Plantar Pressure Disturbance Results of Two Different Surgical Techniques on Syndesmosis Injuries with Malleolus Fractures

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ABSTRACT

Background and objectives: This study compared the clinical and radiological results of three cortex conventional metal screw fixation and EndoButton implant techniques. We applied dynamic pedobarographic analysis to the cases to reveal the effect of the postoperative functional levels on the gait and plantar pressure distribution parameters and to determine the differences between the groups.

Materials and methods: In our retrospective study, 42 patients were evaluated in two groups, divided into metal screw (Group I; n=24) and EndoButton implant technique (Group II; n=18). After the groups were formed, the functional and clinical outcomes of the patients were evaluated and measured prospectively by an investigator blinded to the surgical procedures of the patients clinically and radiologically.

Results: We found the AOFAS score significantly higher in the EndoButton group (p=0.041), while the Weber and Freiburg scores were similar between the two groups (p=0.07 and p=0.49, respectively). When the plantar pressure distribution analyzes of the operated sides were examined, the loading percentages in the forefoot and midfoot were found to be statistically significantly higher in the metallic screw group providing static fixation, while the percentage of lateral heel loading was found to be statistically significantly lower. The medial heel loading percentage was also lower in the screw group, but no statistically significant difference was detected.

Conclusions: We observed that the conventional screw static fixation technique used to repair syndesmosis injuries causes limitation in ankle dorsiflexion, increases the pressure percentages in the forefoot and midfoot, and causes a later return to work/daily life.

Keywords: ankle fracture, syndesmosis outcome, syndesmotic ınjury

Sindesmoz Yaralanmasi Eşlik Eden Malleol Kırıklarında Konvansiyonel Vida Tespiti ile Düğme Dikiş İmplant Tekniğinin Klinik, Fonksiyonel ve Plantar Basınç Dağılımı Sonuçlarının Karşılaştırılması

ÖZET

Amaç: Bu çalışmada üç korteks konvansiyonel metal vida tespiti ile EndoButton tekniğinin klinik ve radyolojik sonuçlarının karşılaştırılmasını amaçladık. Olguların cerrahi sonrası fonksiyonel seviyelerinin, yürüyüş ve plantar basınç dağılımı parametrelerine olan etkisinin ortaya konabilmesi ve gruplar arasındaki farkların saptanabilmesi amacıyla, olgulara dinamik pedobarografik analiz uyguladık.

Yöntem: Retrospektif olarak planlanan çalışmamızda 42 hasta, metal vida (Grup I; n=24) ve EndoButton tekniği (Grup II; n=18) olarak ayrılarak iki grup halinde değerlendirildi. Gruplar oluşturulduktan sonra, hastaların cerrahi prosedürlerine kör bir araştırmacı tarafından olguların fonksiyonel ve klinik sonuçlarına ilişkin değerlendirme ve ölçümler prospektif olarak uygulandı.

Bulgular: EndoButton grubunda AOFAS skorunu anlamlı olarak daha yüksek (p=0.041), Weber ve Freiburg skorlarını ise her iki grup arasında benzer bulduk (sırasıyla p=0.07 ve p=0.49). Opere edilen taraflara ait plantar basınç dağılım analizleri incelendiği zaman ise statik tespit sağlayan metalik vida grubunda ayak önü ve ayak ortası yüklenme yüzdeleri istatistiksel anlamlı olarak daha yüksek bulunmuşken, lateral topuk yüklenme yüzdesi istatistiksel olarak anlamlı şekilde daha düşük tespit edildi. Medial topuk yüklenme yüzdesi yine vida grubunda daha düşüktü ancak istatistiksel olarak anlamlı farklılık tespit edilemedi.

Sonuç: Sindesmoz yaralanmalarının tamirinde kullanılan, konvansiyonel vida ile statik tespit tekniğinin ayak bileği dorsifleksiyonunda kısıtlılığına yol açtığı, ayak önü ve ayak ortası basınç yüzdelerini arttırdığı, daha geç işe/günlük hayata dönüş sürelerine neden olduğu gözlenmiştir.

Anahtar kelimeler: ayak bileği kırığı, sindezmoz sonuçları, sindezmotik yaralanma

The syndesmosis is a form of articulation surrounded by connective tissue in the lower part of the tibia and fibula. This joint and the ligaments that make it up are critical to the stability of the ankle. Injuries involving the ligaments in the joint, where the ligaments are torn and joint congruence is impaired, are called syndesmosis injuries (1).

It is common to use "metal screws" or "EndoButton implants" in the surgical treatment of syndesmosis injuries (1,2). As a conventional method in surgical treatment, fixation by metal screws is still in use. Although successful results of this repair method have been reported in the literature (1-4).

The repair method with EndoButton implants is a good alternative because it preserves the physiological movements of the syndesmosis joint (5). The ideal method for syndesmosis repair should allow early joint movement and be sturdy enough to maintain its reduction. Both methods, compared in this study, are used with similar indications, and a consensus could not be reached in terms of clinical and functional results.

This study aimed to compare the clinical, functional, and radiological results of the three cortex metal screw fixation method and the EndoButton implant technique, the two most frequently used surgical methods in the literature in malleolar fractures accompanied by syndesmosis injury.

MATERIALS AND METHODS

Study Design

This is an original research initiative designed as a prospective and double-blind study comparing current results of retrospective cases and 1-year longitudinal results. Informed consent forms were obtained from all of the patients after explaining the details of the study, and the necessary ethical permissions were obtained from the local ethics committee.

Subjects

In this study, 42 cases that meet inclusion criteria were included retrospectively from the archive of our clinic. The patients were treated between January 2017 and January 2018 and underwent surgery and regular follow-up using the methods aimed for comparison in this study. All patients' surgery notes and preoperative and postoperative radiographs were completed, and their surgical procedures were less than 12-months old.

As a surgical repair method, the EndoButton implant technique or three cortex screw fixation was performed, and patients between the ages of 18-60 that worked actively, who were in the ASA (American Society of Anesthesiologists) I-II-III physical risk group, and that volunteered to participate in the outcome measurement evaluations of the study were included in the study. Patients with a history of previous ankle surgery on the same side, individuals who had had arthrosis of the ankle at the time of injury, those admitted with multiple trauma, patients with visual, auditory, or perceptual pathology, those in the ASA IV-V physical risk group, and anyone who did not volunteer to participate in the evaluations were excluded from the study. The fixation of syndesmosis in 24 cases (12 men and 12 women) was made with three cortex screws, and these cases formed the **Screw Group**. The syndesmosis fixations of 18 cases—6 male and 12 female— were made using the EndoButton technique, and these cases made up the **EndoButton Group**. The 42 cases that formed both groups were called to the clinic by phone for the functional outcome measurements and pedobarographic analyses of the study.

Outcome Measurements

The histories (sex, affected direction, activity levels, time to return to work) and early postoperative period (3rd month) X-ray data of the patients in both groups were collected from the system as baseline measurement values. Then, the post-op 12th-month histories of all cases were gathered by two researchers who were blind to the surgical technique applied to the cases; following this, physical examinations were carried out, and the measurements were taken after the late period (12th month) control X-rays were taken. In order to reveal the functional results of the cases, AOFAS (American Orthopedic Foot and Ankle Society) Weber and Freiburg Scores were applied for the post-op 12th month. Affected extremities were measured with the ankle active and passive range of motion (ROM) and step forward test and subsequently recorded in degrees. Dynamic pedobarographic analyses were performed to obtain the 1-year long-term post-op effects of the two compared surgical methods on gait and plantar pressure distribution (Figure 1).

Radiological Evaluations: TFO (Tibiofibular Overlap), TFCS (Tibiofibular Clear Space), and MCS (Medial Clear Space) values were measured; mortise stability and the presence of arthrosis were evaluated on the standard radiographs of the cases in the form of anterior-posterior, lateral, and mortise radiographs. The measurements taken via the early (3rd month) (MA, UG) and late period 12th month (MA, UG) control radiographs of the cases were made by 2 different researchers, and their arithmetic means were recorded.

Pedobarographic Analysis: In order to obtain sensitive and reliable objective data on pressure distribution alterations in gait from 2 different surgical patient groups, dynamic plantar pressure distribution analysis was performed at the post-op 12th month, and the loading percentages of great toe, other fingers, first metatarsal head, 2nd and 3rd metatarsal head, 4th and 5th metatarsal head, medial arch, lateral arch, medial heel and lateral heel, load response time, maximum load response surface, load response maximum load, terminal stance time, terminal stance maximum surface and terminal stance maximum load values were obtained (Figure 1).The subjects were made comfortable during the test and were informed before about their daily gait patterns. They were allowed to walk until they had adjusted in the testing room. They were then asked to walk at least 3 laps on the platform, and the test values of the gait position that were closest to the ideal were recorded by the system.

For pedobarographic analyses, using the FreeMed brand pedobarography device, which can sample at a frequency over 400Hz, has an 8-meter walking platform, and consists of 24-carat gold-plated rubber sensors embedded in the middle of the platform, patient data were recorded according to date and time and stored in the system with static, dynamic, postural, and visual evaluation through 7 integrated cameras. During the preparation of the data for statistical analysis, the plantar pressure distribution data obtained from the cases were processed and listed as the affected and unaffected side.

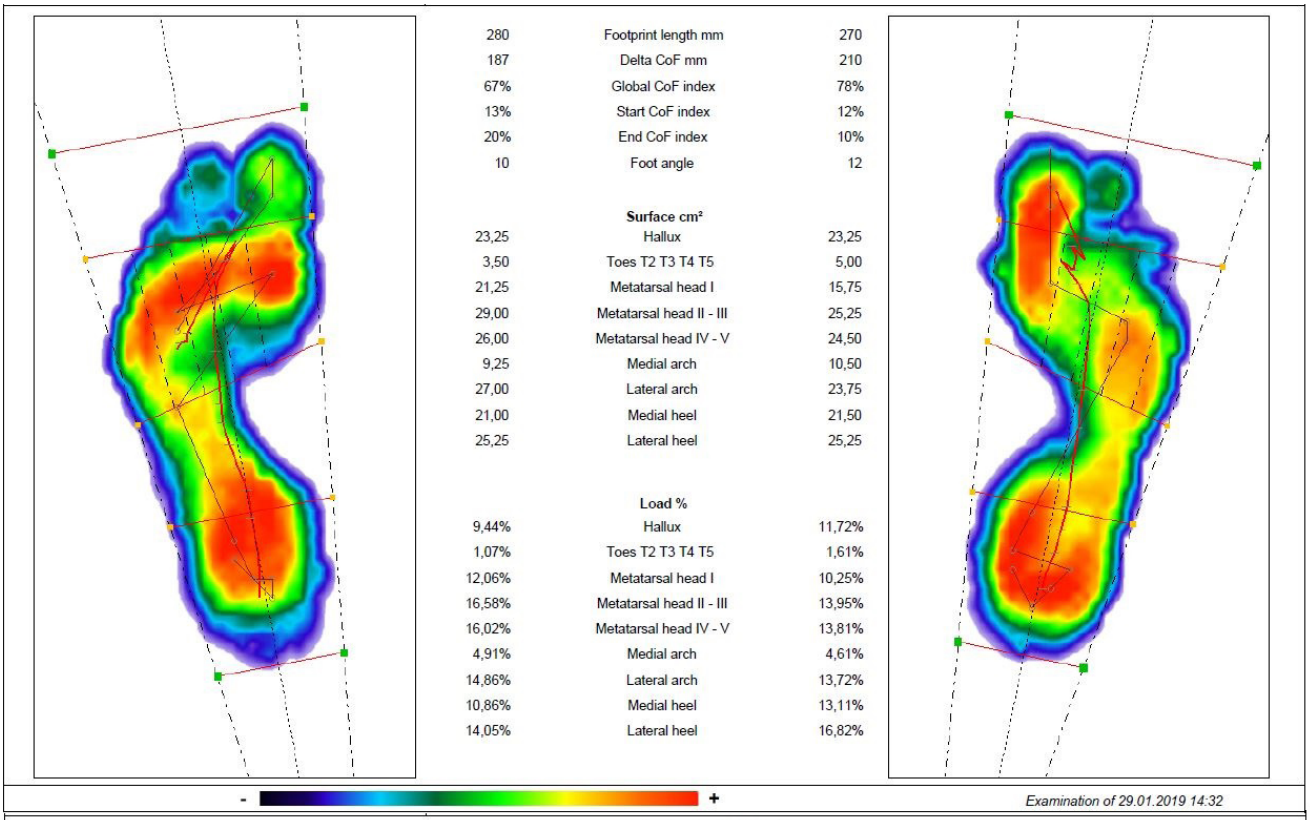
Statistical Analysis

Data analysis was performed using the IBM SPSS 24.0 statistical package program. While evaluating the study data, descriptive statistical methods (frequency, percentage, mean, standard deviation) were used in the first stage. In addition, in the comparison of qualitative data and comparisons between groups, statistical differences were evaluated using a T-Test for the dependent groups and a T-Test for the independent groups. The plantar pressure distribution values obtained from the subjects were compared both for in-group affected and unaffected directions and between the groups for the affected and unaffected sides. Comparisons of functional results, active and passive ROM values, and radiological measurements were made only for the 12th month values between the groups. Results were given as mean ± standard deviation (SD). A p-value of <0.05 was considered to be statistically significant. Values with a probability (P) less than $\alpha = 0.05$ were accepted as significant and showed difference between groups; values with a higher probability were considered insignificant and demonstrated no difference between groups.

RESULTS

The demographic data of the cases in this study are presented in Table 1 according to the groups. While the mean time to return to work for the patients in Group 1 was 81.25 days, this period was calculated as 52.61 days in Group 2. In the examination of the post-op complications of the cases, it was seen that 22 of 24 cases in Group 1 (8 for pain, 14 at the request of the patient) had a secondary surgery for implant removal. One patient had secondary surgery due to superficial wound infection, and the other remaining patient had secondary surgery due to wound necrosis. It was observed that superficial wound infection developed in 1 of 18 patients in Group 2; none of the patients required secondary surgery. 22 patients (91.6%) in the screw group had implant removal procedure performed. Of these procedures, 33.3% was performed due to ankle pain caused by weight-bearing, and 58.3% was performed at the patients' request. None of the patients in the EndoButton group required a similar procedure to be performed.

The results of the in-group comparison of the postoperative early (3rd month) radiographs and the last (12th month) radiological measurements are presented in Table 2. The radiological data we obtained were compared within and between groups in terms of early and late control measurements. While no statistically significant difference was observed between the early and final control TFCS, TFO, and MCS values in the Screw Group, the early TFO value in the EndoButton group decreased from 8.41 mm, on average, to 7.46 mm, which was the mean value for the final control value; this was statistically significant ($p < 0.05$). Again, in the EndoButton group, the mean value of early MCS showed a statistically significant increase from 3.38 mm to an average of 3.5 mm at the final follow-up ($p < 0.05$). There was no significant change in the TFCS value ($p > 0.05$). When compared between groups, the mean TFO value in the early control was calculated as 8.78 mm in the Screw Group and 8.41 mm in the EndoButton group, and the difference between these values, which was within the normal radiological limits for both groups, was statistically significant ($p < 0.05$). Early MCS values were also found to be within normal values, with an average of 3.77 mm and 3.38 mm, respectively, but the difference between them was statistically significant ($p < 0.05$). When comparing late control radiographs between groups, mean TFCS values were found to be 3.21 mm in the Screw Group, 3.86 mm in the EndoButton group, and the mean MCS values were found to be statistically different as 3.7 mm and 3.5 mm, respectively ($p < 0.05$).



280	Footprint length mm	270
187	Delta CoF mm	210
67%	Global CoF index	78%
13%	Start CoF index	12%
20%	End CoF index	10%
10	Foot angle	12
	Surface cm²	
23,25	Hallux	23,25
3,50	Toes T2 T3 T4 T5	5,00
21,25	Metatarsal head I	15,75
29,00	Metatarsal head II - III	25,25
26,00	Metatarsal head IV - V	24,50
9,25	Medial arch	10,50
27,00	Lateral arch	23,75
21,00	Medial heel	21,50
25,25	Lateral heel	25,25
	Load %	
9,44%	Hallux	11,72%
1,07%	Toes T2 T3 T4 T5	1,61%
12,06%	Metatarsal head I	10,25%
16,58%	Metatarsal head II - III	13,95%
16,02%	Metatarsal head IV - V	13,81%
4,91%	Medial arch	4,61%
14,86%	Lateral arch	13,72%
10,86%	Medial heel	13,11%
14,05%	Lateral heel	16,82%

	Initial Contact (0-2%)		Loading Response (3-10%)		Mid Stance (11-30%)		Terminal Stance (31-50%)	
Left footprint	Frames	0-1	Frames	1-4	Frames	4-13	Frames	13-22
	Duration ms	28	Duration ms	87	Duration ms	294	Duration ms	403
	Avg. speed mm/s	328	Avg. speed mm/s	589	Avg. speed mm/s	666	Avg. speed mm/s	321
	Max surf. cm²	42	Max surf. cm²	104	Max surf. cm²	138	Max surf. cm²	141
	Max load %	15	Max load %	50	Max load %	100	Max load %	100
Right foot	Frames	0-1	Frames	1-4	Frames	4-12	Frames	12-21
	Duration ms	30	Duration ms	92	Duration ms	239	Duration ms	318
	Avg. speed mm/s	93	Avg. speed mm/s	333	Avg. speed mm/s	855	Avg. speed mm/s	325
	Max surf. cm²	40	Max surf. cm²	74	Max surf. cm²	137	Max surf. cm²	137
	Max load %	20	Max load %	53	Max load %	98	Max load %	100

= time of left foot support = time of right foot support = time of the dual support = time of oscillation

Figure 1. Plantar Pressure Test Results

Table 1. Demographics of Patients

Groups	Sex		Affected Part		Shoe Habit		Activity Habit	
	Female	Male	Right	Left	Soft	Hard	Active	Passive
Screw Group(%) (n=24)	50% (n=12)	50% (n=12)	62.5% (n=15)	37.5% (n=9)	0.83% (n=17)	29.17% (n=7)	83.33% (n=20)	16.67% (n=4)
Endo-Button Group(%) (n=18)	66.67% (n=12)	33.33% (n=6)	33.33% (n=6)	67.6%7 (n=12)	94.44 %(n=17)	5.56% (n=1)	83.33% (n=15)	16.67% (n=3)

Table 2. Radiological Evaluation of Injured Ankles

		Metal screw group (n=24)			EndoButton group (n=18)		
		First evalution X±SD	Final evalution X±SD	p	First evalution X±SD	Final evalution X±SD	p
Radiological	TFCS (mm)	3.45±1.08	3.21±0.76	0.071	3.48±0.42	3.86±0.32	0.069
	TFO (mm)	8.78±1.59	8.88±2.0	0.271	8.41±0.78	7.76±1.37	0.000*
	MCS (mm)	3.77±1.06	3.70±1.41	0.096	3.38±0.56	3.50±0.93	0.011*
		First evaluation (n)	Final evaluation (n)		First evaluation (n)	Final evaluation (n)	
	Mortise stability (n)	24	23		18	18	
	Arthrosis (n)	0	14		0	4	

*: p<0.05, TFCS:Tibiofibuler Clear Space TFO: Tibiofibuler Overlap, MCS:Medial Clear Space

The results of the comparison of radiological measurements and ankle ROM results obtained in the early (3rd month) and late (12th month) postoperative period from the cases in the groups are presented in Table 3.

When the non-numerical data were compared, the mortise stability was fully observed in the early radiographs in both groups.

Mortise stability was lost in the final control radiographs in 3 patients in Group 1, and stability was preserved in all patients in Group 2. Arthrosis was not detected in any of the early radiographs. However, when the final control radiographs were examined, it was observed that arthrosis developed in 14 (58%) patients in Group 1 and in 4 (22%) patients in Group 2 (Table 3). The results regarding the comparison of the results of the 12th month functional scoring scales between the groups are shown in Table 4.

Table 3. Intergroup Comparisons of the Data Obtained from the Radiological Evaluation of the Cases, Range of Motion, and Step Forward Tests

		Metal Screw Group (n=24)	EndoButton Group (n=18)	p
Early Control	TFCS (mm)	3.45±1.08	3.48±0.42	0.093
	TFO (mm)	8.78±1.59	8.41±0.78	**0.015***
	MCS (mm)	3.77±1.06	3.38±0.56	**0.028***
	Mortis stability (+/-)	24 +	18 +	-
	Arthrosis (+/-)	none	none	-
Late Control	TFCS (mm)	3.21±0.76	3.86±0.32	**0.000***
	TFO (mm)	8.88±2.0	7.76±1.37	0.079
	MCS (mm)	3.70±1.41	3.50±0.93	**0.000***
	Mortis stability (+/-)	23 +	18 +	-
		14 +	4 +	-
Step Forward Test (cm)		1.81	6.83	0.231
Active	Dorsiflexion (°)	3.75±6.12	17.5±7.12	0.460
	Plantarflexion (°)	31.25±9.11	34.17±9.58	0.420
Passive	Dorsiflexion (°)	6.25±6.12	22.5±7.71	0.515
		33.13±8.05	38.33±7.07	0.717

*: p<0.05; TFCS: Tibiofibular Clear Space TFO: Tibiofibular Overlap, MCS: Medial Clear Space.

The results of the comparison of dynamic plantar pressure distribution analysis values and the affected and unaffected sides of the cases are shown in Table 5. In addition, the statistical analysis results of the in-group comparisons of the plantar pressure distribution data of the affected and unaffected sides of the cases in both groups are presented in Table 6. In the Screw Group, a statistically significant increase was observed in the great toe loading percentage of the affected side ($p < 0.05$). In other fingers, the loading percentage was statistically significantly decreased ($p < 0.05$). While the loading percentage of the 1st metatarsal (MT) head was significantly decreased on the affected side ($p < 0.05$), this rate increased significantly at the 4th-5th MT heads ($p < 0.05$). The medial arch loading percentage was found to be significantly increased ($p < 0.05$), and the medial heel loading percentage was found to be significantly decreased ($p < 0.05$). When the data of the affected and unaffected sides of the EndoButton group were compared, it was observed that the loading percentage at the 1st MT head on the affected side was significantly decreased ($p < 0.05$), whereas at the 2nd-3rd MT heads, the loading percentage was significantly increased ($p < 0.05$). The medial arch and lateral arch loading percentage was significantly decreased on the affected side ($p < 0.05$), while the lateral heel loading percentage was significantly increased ($p < 0.05$)

In the comparison of dynamic pedobarographic data of the operated feet of the patients between groups, it was observed that in the Screw Group, great toe, other toes, 1st MT head, 2nd-3rd MT heads, medial arch, and lateral arch loading percentages were higher. All of these differences were statistically significant compared to the EndoButton group ($p < 0.05$). It was found that the mean loading percentages at the 4th-5th MT heads were also higher in the Screw Group; however, this was not statistically significant. The medial heel loading percentage was lower in the Screw Group compared to the other group, but it was not statistically significant. The lateral heel loading percentage, on the other hand, was significantly decreased ($p < 0.05$).

Table 4. Intergroup Comparisons of the Total Scores of the AOFAS, Weber and Freiburg Scales of Groups

	Screw Group (n=24)	Endo-Button Group (n=18)	p
AOFAS	85±13.13	92.33±7.73	**0.041***
WEBER	5.88±4.16	2.67±2.63	0.07
FRIEBURG	86,25±11,01	88,50±9,82	0.49

**: p<0.05*

DISCUSSION

This study aimed to compare the clinical, functional, and radiological results of the three-cortex screw fixation and the EndoButton technique, which are commonly used procedures in the fixation of concomitant syndesmosis injury in patients with malleolar fractures. Therefore, in this study, the cases that were followed-up for 1 year were divided in 2 groups: the metallic Screw Group and the EndoButton group. Patients were compared according to their histories, physical examination findings and radiological measurements taken from the postoperative early (3rd month), late (12th month) control radiographs, functional scores, and dynamic plantar pressure distribution analysis data. In addition to the parameters already studied on the EndoButton technique's effects on the anatomical reduction of the syndesmosis joint and the preservation of physiological movements, for the first time in the literature, the technique's effects on plantar pressure distribution was also studied.

When the early and late TFCS, TFO and MCS measurement data of the cases were examined in each group, it was seen that these changes remained within normal limits, although they were statistically significant. In both groups, it was observed that all patients had mortise stability in the early control radiographs, but the mortise stability could not be preserved in the final control radiographs of 1 patient in the Screw Group. In the EndoButton group, there was no case exhibiting loss of mortise stability. It is thought that these measurements, which were found to be within normal range, are not clinically significant, even though they are statistically significant. However, the decrease in TFO value and increase in MCS value in the dynamic fixation group show that there is a need for further studies in order to observe whether there is some loosening of the EndoButton.

Arthrosis developed in 14 patients (58%) in the Screw Group and 4 patients (22%) in the EndoButton group in the final follow-up radiographs. These findings and the results of the present study show similarities with the literature (6).

Table 5. Comparison of the Screw and Endo-Button Groups of Dynamic Plantar Pressure Distribution Data of Cases in Affected and Unaffected Sides

	Affected Side			Non-affected Side		
	Screw Group (n=24)	Endo-Button Group (n=18)	p	Screw Group (n=24)	Endo-Button Group (n=18)	p
Great Toe (%)	14.33±6.58	8.24±3.07	**0.014***	11.45±5.24	8.45±4.31	0.59
Other Fingers (%)	4.67±5.69	2.78±1.68	**0.000***	7.67±7.40	2.60±2.14	**0.000***
1st Metatarsal Head (%)	15.91±6.77	6.68±2.34	**0.000***	11.41±6.24	8.84±2.55	**0.000***
2nd and 3rd Metatarsal Head (%)	24.02±6.81	15.62±2.30	**0.000***	22.99±5.17	17.50±4.90	0.867
4th ve 5th Metatarsal Head (%)	17.98±4.15	13.45±3.53	0.368	22.48±7.05	12.41±2.82	**0.000***
Medial Arch (%)	10.29±6.97	5.56±1.70	**0.002***	6.23±4.03	5.80±2.65	0.287
Lateral Arch (%)	19.92±9.46	14.10±415	**0.000***	20.73±5.78	14.62±5.40	0.551
Medial Heel (%)	15.75±5.71	16.25±3.54	0.08	21.15±6.08	15.53±2.27	**0.000***
Lateral Heel (%)	16.14±10.12	17.13±4.93	**0.002***	17.44±8.40	14.27±3.64	**0.000***
Load Response Time (ms)	118.88±23.23	152±53.75	**0.000***	113±20.09	151.83±44.24	**0.001***
Load Response Max. Surface (cm^2)	106.50±28.63	87.83±9.326	**0.000***	103.00±14.78	93.83±22.04	**0.002***
Load Response Max. Load (%)	60.38±17.85	48±11.067	**0.011***	56.25±5.25	45±18.50	**0.000***
Terminal Stance Time (ms)	309.13±42.70	380.17±163	**0.001***	302.88±68.44	390.83±99.84	0.064
Terminal Stance Max. Surface (cm^2)	125.75±20.78	127±17.72	0.31	125.38±17.54	124.67±8.2	**0.006***
Terminal Stance Max. Load (%)	97.63±3.18	95.50±6.051	**0.000***	94.50±6.04	99.67±0.76	**0.000***

**: p<0.05*

Tablo 6. Comparison of Affected and Unaffected Sides of Dynamic Plantar Pressure Distribution Data of Cases in Screw and Endo-Button Groups

	Screw Group (n=24)			Endo-Button Group (n=18)		
	Affected	Non-affected	p	Affected	Non-affected	p
Great Toe (%)	14.33±6.58	11.45±5.24	**0.033***	8.24±3.07	8,45±4,31	0,865
Other Fingers (%)	4.67±5.69	7.67±7.40	**0.007***	2.78±1.68	2,60±2,14	0,053
1st Metatarsal Head (%)	15.91±6.77	11.41±6.24	**0.000***	6.68±2.34	8,84±2,55	**0,048***
2nd and 3rd Metatarsal Head (%)	24.02±6.81	22.99±5.17	0.275	15.62±2.30	17,50±4,90	**0,002***
4th ve 5th Metatarsal Head (%)	17.98±4.15	22.48±7.05	**0.000***	13.45±3.53	12.41±2.82	0.136
Medial Arch (%)	10.29±6.97	6.23±4.03	**0.027***	5.56±1.70	5.80±2.65	**0.000***
Lateral Arch (%)	19.92±9.46	20.73±5.78	0.599	14.10±4.15	14.62±5.40	**0.007***
Medial Heel (%)	15.75±5.71	21.15±6.08	**0.009***	16.25±3.54	15.53±2.27	0.381
Lateral Heel (%)	16.14±10.12	17.44±8.40	0.567	17.13±4.93	14.27±3.64	**0.000***
Load Response Time (ms)	118.88±23.23	113±20.09	0.116	152.00±53.75	151.83±44.24	**0.000***
Load Response Max. Surface (cm^2)	106.50±28.63	103±14.78	0.556	87.83±9.326	93.83±22.04	0.441
Load Response Max. Load (%)	60.38±17.85	56.25±5.25	0.246	48±11.067	45±18.50	**0.003***
Terminal Stance Time (ms)	309.13±42.70	302.88±68.44	0.501	380.17±163	390.83±99.84	**0.000***
Terminal Stance Max. Surface (cm^2)	125.75±20.78	125.38±17.54	0.912	127±17.72	124.67±8.2	**0.000***
Terminal Stance Max. Load (%)	97.63±3.18	94.50±6.04	**0.007***	95.50±6.051	99.67±0.76	0.165

**: p<0.05*

In the present study, the mean AOFAS score of the EndoButton group was 92.33 and 85 in the Screw Group. It was observed in the literature that EndoButton scores are between 85.57 and 97 and between 75 and 92 in screw fixation groups (7-14). The results in this study are therefore similar to the literature. The AOFAS scores of the EndoButton group are significantly better. In a review by Stiene et al., in which studies carried out in the last 10 years in the literature were reviewed in 2018, 494 patients in 11 studies were evaluated, and when the weighted averages of AOFAS scores between static and dynamic fixation were examined, no statistically significant difference was found despite the fact that the results were higher in favor of the dynamic group ($p > 0.05$) (15).

The in-group comparisons of the dynamic plantar pressure distribution analysis data that were obtained in the present study in terms of the affected and unaffected sides and the differences between the groups on the affected side and the unaffected side were analyzed separately. The decrease in loading percentages under the first metatarsal and medial heel in the surgically operated feet of the patients in the metal screw group, as well as the increase in weight in the 4th and 5th MT heads, along with the pressure distribution analyses on the soles of the feet after the surgical operation, indicate that the foot is positioned towards more supination. Furthermore, the increase in great toe and medial longitudinal arch loading percentage supports this idea. In the foot positioned in supination, the dynamic biomechanics of the subtalar joint and, accordingly, the midtarsal joint will cause rigidity in the foot. It is thought that this situation may cause problems in terms of flexibility and shock absorption of the foot, especially in the forefoot in the future. It was found that the maximum loading percentage of the terminal stance phase increased on the affected side, which was also statistically significant ($p < 0.05$). Terminal stance is the phase in which the extremity ends the stance phase and starts to swing, and studies show that pain or foot pathologies lead to a shortening of the total stance phase time and a reduction in the load in this phase. Considering the prolongation of the stance phase after metal screw fixation in this study's cases, the increase in the foot loading percentage can be considered positive; on the other hand, the increase in loading and time in this period can also cause a decrease in walking speed.

On the surgically operated sides of the cases in the EndoButton group, the decrease in the 1st MT head's medial and lateral arch loading percentage, compared to the unaffected sides, means that the weight shifted from medial to lateral; however, with the decrease in the percentages in the lateral, the foot was not positioned in complete supination, and a more plantigrade foot was shaped in terms of plantar pressure distribution percentages. In addition, in the cases in this group, the increase in the loading percentage under the 2nd-3rd MT heads compared to the other feet shows that the problem of decreased forefoot flexibility in the screw fixation group did not occur in these cases. Based on these data, it can be said that the present study revealed that the percentages of forefoot and midfoot pressures increased in cases with static fixation compared to cases with dynamic fixation, while the percentages of pressure on the back of the foot decreased. This highlights the necessity for considering the effects of ankle injuries on gait parameters in detail in the selection of surgical technique. In addition, in such approaches, since routine clinical evaluations are not sensitive to the changes that were mentioned, decisions should be made based on the results of evaluation methods that provide more objective data. There is no study in the literature that compares these data.

In the routine practice for syndesmosis injuries with screw fixation, the decision whether or not to remove the syndesmosis screws is made through patient-physician communication. It is explained that both approaches are available in the literature, and the aim is to decide on these approaches together with the patient in line with the positives and negatives of each approach. In addition, conventional screws are removed in the 3rd month in patients who have pain in the ankle due to weight bearing. In the current literature, there is no clear consensus on the necessity of removing conventional screws. In 2 separate studies on this subject, while one group of researchers advocated for the necessity of removing the screws, the other argued that this is not a necessary procedure (16,17).

Limitations of the Study

The fact that this study was conducted with the data obtained from the 1-year follow-up of 2 groups consisting of 42 cases meant that it was not possible to compare the long-term results of the treatment techniques of the related injury. There is a need for broader studies and longer follow-up studies in the literature.

In this study, the radiological measurements and the data that were obtained from the direct radiographs were also compared. Kocadal et al., showed that fibular rotation is seen as a potential problem in cases with screw fixation and that computed tomography is superior to direct

radiography in the post-surgical evaluation (18). Another limitation of the present study is that radiological evaluations were made only on direct radiographs.

CONCLUSION

In addition to physical examination, radiological examinations and clinical scoring, the use of pedographic pressure distribution analysis, which provides objective and measurable data, will be useful in the evaluation of patients. There is a need for reliability and correlation studies on these data that need to be conducted in larger populations, including control groups. In malleolar fractures accompanied by syndesmosis injury, instead of conventional metallic screws that provide static fixation, the EndoButton technique's dynamic fixation seems to be a more rational approach since it allows for an earlier return to work/daily life and physiological movements of the joint; it also does not restrict ankle dorsiflexion and thus does not increase forefoot and midfoot pressure during gait.

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Conflict of Interest

All authors declare that there is no conflict of interest.

Ethical Approval

All protocols for this study were approved by the Ankara Numune Eğitim Araştırma Hastanesi Ethics Committee (Decision No: E-18-2179).

Author Contributions

Concept – YMA, FÖ, UG.; Design – YMA, FÖ,; Supervision – FÖ, NB,.; Resources – YMA, FÖ, NB, İAY, UG.; Materials YMA, İAY, UG.; Data Collection and Processing - YMA, İAY, UG.; Analysis and/or Interpretation – YMA, FÖ, NB, İAY, UG.; Literature Review – YMA, UG.; Writing – YMA, UG.; Critical Review - YMA, FÖ, NB, İAY, UG.

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