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Original Article / Özgün Araştırma

Comparison of the effectiveness of foot orthosis use in pes planus treatment with combination of kinesio taping

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Abstract

Aims: The aim of this study was to compare the clinical evaluations, disease impact, disability and foot function of symptomatic flexible pes planus (SFPP) deformity patients treated with the University of California at Berkeley Laboratory (UCBL) foot orthosis and Kinesio tape (KT) to those treated only with the UCBL orthosis.

Methods: A total of 100 feet in 50 subjects with a mean age of 77.10 months were included in the study. The subjects were divided into two groups: Group 1 (UCBL foot orthosis with KT, n=27) and Group 2 (UCBL-alone, n=23). Group 1 consisted of 27 patients (14 girls, 13 boys) with an average age of 62 months (range: 25 to 165), while Group 2 consisted of 23 patients (10 girls,13 boys) with an average age of 63 months (range: 30 to 166). Various assessments, including American Orthopaedic Foot and Ankle Society (AOFAS) scores, anteroposterior and lateral talocalcaneal and talo-first metatarsal angles, talonavicular angle, calcaneal pitch angle and clinical examinations, were conducted to foot-specific disease activity, and foot function.

Results: Group 1 exhibited mild-to-moderate foot disability and impairments, along with low levels of disease activity. Treatment with UCBL orthosis and Kinesio tape led to significant improvements in all AOFAS scores and foot angles. Substantial improvement in AOFAS scores was observed during the follow-up examination, except for the midfoot score.

Discussion: The use of UCBL foot orthosis in conjunction with Kinesio tape appears to be a preferable treatment strategy for children and adolescents with SFPP. This combined approach is associated with a lower rate of complications, higher patient comfort levels, and faster improvement in both radiological and clinical findings when compared to the use of the UCBL orthosis alone.

Keywords: Flatfoot deformity, Foot orthosis, Kinesio taping, Pes planus, UCBL

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Pes planus tedavisinde ayak ortezi kullanımının kinesyo bantlama ile kombinasyonunun etkinliğinin karşılaştırılması

Öz

Amaç: Bu çalışmanın amacı, Semptomatik Fleksible Pes Planus (SFPP) deformitesi olan hastaların klinik değerlendirmelerini ve ayak fonksiyonunu, University of California at Berkeley Laboratory (UCBL) ayak ortezi ve Kinesio bant (KT) ile tedavi edilenlerle, sadece UCBL ortezi ile tedavi edilenler arasındaki farkı karşılaştırmaktı.

Yöntemler: Çalışmaya 77.10 ay ortalama yaşa sahip 50 hastanın toplamda 100 ayağı dahil edildi. Grup 1 (UCBL ayak ortezi ile KT, n=27) ve Grup 2 (yalnızca UCBL, n=23) olmak üzere iki gruba ayrıldı. Grup 1, yaş ortalaması 62 ay olan 27 hasta (13 erkek, 14 kız) içeriyordu (aralık: 25 ila 165), Group 2 ise yaş ortalaması 63 ay olan 23 hasta (13 erkek, 10 kız) içeriyordu (aralık: 30 ila 166). Ayaga özgü hastalık aktivitesi ve ayak fonksiyonunu belirlemek için Amerikan Ortopedik Ayak ve Ayak Bileği Derneği (AOFAS) skorları, anteroposterior ve lateral talokalkaneal ile talo-first metatarsal açıları, lateral düzlemde kalkaneal pitch açısı, talonaviküler açı ve klinik muayeneleri içeren çeşitli değerlendirmeler yapıldı.

Sonuç: Grup 1 hafif ila orta derecede ayak bozukluğu ve engeli gösterdi, ayrıca düşük düzeyde hastalık aktivitesi vardı. UCBL ortezi ve Kinesio bant ile yapılan tedavi, tüm AOFAS skorlarında ve ayak açılarında önemli iyileşmelere yol açtı.

Tartışma: UCBL ayak ortezinin Kinesio bant ile birlikte kullanımı, SFPP'ye sahip çocuklar ve ergenler için tercih edilen bir tedavi stratejisi gibi görünmektedir. Bu kombinasyonlu yaklaşım, yalnızca UCBL ortezi kullanımıyla karşılaştırıldığında daha düşük komplikasyon oranları, daha yüksek hasta konfor düzeyleri ve hem radyolojik hem de klinik bulgularda daha hızlı iyileşme ile ilişkilidir.

Anahtar kelimeler: Düz tabanlık, Ayak ortezi ,UCBL, Kinesio tape.

INTRODUCTION

Flatfoot deformity refers to a condition in which the inner arch of the foot has collapsed, either when bearing weight or not, due to a complex interplay between the midfoot, forefoot, and hindfoot[1]. Symptomatic flexible pes planus (SFPP) is a dynamic functional abnormality that can result in limited mobility, substantial discomfort, pain in the calf and foot, and a decline in overall quality of life1. SFPP is often linked to hindfoot valgus deviation and an increased angle of the talus[2]. Additionally, the misalignment of the talus disrupts the kinetic chain, leading to shortening of the Achilles tendon and impairment of the posterior tibial tendon[3]. Severe flatfoot can cause reduced arch height, increased abduction of the forefoot with valgus deviation of the hindfoot, triggering symptoms that alter the mechanical axis of the limbs[4]. Several factors influence the shape of the arch, including height, weight, age, gender, joint hypermobility, hindfoot alignment, foot progression angle, and the presence of knock knees[5]. In young children aged 3 to 6 years, muscle training and exercises have been found to be as effective as orthotic and surgical interventions[6]. The degree of arch collapse can be assessed using weight-bearing X-rays, while computed tomography (CT) aids in comprehending the relationships between the intertarsal bones[7].

Various treatment options exist for SFPP, such as foot orthoses and shoe modifications, soft-tissue reconstructions, calcaneal osteotomies, and joint fusions[8]. The choice of treatment technique depends on the risk of structural deformities and the potential impact on other anatomical regions related to foot pressure distribution. Techniques aimed at correcting excessive pronation encompass orthotic prescription and taping.

The use of Kinesio tape (KT) has gained traction as a supplementary treatment in orthopedic and sports medicine contexts. This method involves applying Kinesio tape in a specific

manner[9]. The tape is similar in thickness to the epidermis. While low and high-dye taping techniques have also been discussed for addressing foot pronation, the utilization of KT for SFPP remains unexplored[10].

Our research inquiry aimed to address the question, "How can we mitigate or prevent complications associated with University of California at Berkeley Laboratory (UCBL) foot orthosis, such as pressure sores around the talus and the medial and lateral malleolar regions, while enhancing the device's duration of use and its effectiveness in correcting deformities?" Through a retrospective study, we examined the correlations between different foot angles, their corresponding American Orthopaedic Foot and Ankle Society (AOFAS) pain scores efficacy of a medial arch orthosis utilizing UCBL orthosis with and without KT.

METHODS

A total of 61 patients diagnosed with SFPP were admitted to our clinic between May 2012 and June 2019.This study was approved by the Gazi Yasargil training and research hospital ethics committee on 12.06.2020 with the decision number 491.These patients were consistently treated with both KT and UCBL orthosis, following definitive diagnosis through X-ray and clinical assessments. Inclusion criteria specified the absence of rigid pes planus deformity, stiffness in tibiotalar or subtalar joints, symptoms exacerbated by prolonged standing, walking, or running, noticeable deformity in the longitudinal arch of the foot, or metatarsalgia complaints.

The study excluded 11 patients due to lost follow-up. The final study group consisted of 50 subjects with 100 feet in total, averaging 77.10 months in age. These participants were categorized into two groups: Group 1 (n=27) receiving UCBL foot orthosis with KT, and Group 2 (n=23) receiving UCBL orthosis alone. Group 1 had 27 patients (13 boys, 14 girls) with an average age of 62 months, while Group 2 included 23 patients (13 boys, 10 girls) with an average age of 63 months. Group 2 initially received both UCBL and KT but shifted to UCBL-alone treatment due to allergic reactions or parental inadaptability. A comparison of the two groups is outlined in Table 1.

Table I: Evaluation of the demographic data.

		Group 1 (n=27)	Group 2 (n=23)
Gender; n (%)	Boy	13 (48.1)	13 (56.5)
	Girl	14 (51.9)	10 (43.5)
Age (months)	Mean±SD	78.67±47.56	75.26±41.46
	Min-Max (Median)	25-165 (62)	30-166 (63)

**Pearson chi-square test, †Mann-Whitney U test*

Patient information, such as age, gender, disease duration, and previous therapies, was recorded. The functional state of the foot and ankle was evaluated using the AOFAS score every six weeks for a year (Table 2). A handheld goniometer assessed weight-bearing varus/valgus alignment of the heel. Methods from Sangeorzan et al. were employed to measure the axes of the calcaneus, talus, and first metatarsal with observers unaware of the treatment[11].

Table II: Evaluation of the AOFAS scores.

AOFAS	Group 1 (n=27) Mean±SD	Group 2 (n=23) Mean±SD
Baseline	58.00±5.83	56.00±5.69
6th week	62.00±5.83	58.00±5.69
12th week	66.00±5.83	58.00±5.69
18th week	68.00±5.83	60.00±5.69
24th week	68.00±5.83	60.00±5.69
30th week	70.00±5.83	60.00±5.69
36th week	70.00±5.83	62.00±5.69
42nd week	72.00±5.83	62.00±5.69
48th week	74.00±5.83	64.00±5.69
52nd week	78.00±5.83	64.00±5.69

**Student's t-test ap<0.05, bp<0.01*

Tarsal bone correlation was gauged via weight-bearing standing anteroposterior (AP) and lateral X-rays, assessed every six months. Radiographic foot alignment followed the methodology validated by Davids et al., measuring lateral calcaneal pitch angle (CPA), AP/lateral talocalcaneal angle (TCA), AP/lateral talo-first metatarsal angle (TFMA), and AP talonavicular angle (TNA)[12].

All patients received customized UCBL foot orthoses designed to limit hindfoot motion, correct talar inclination, and prevent longitudinal arch collapse (Figure 1). Molded with Plastazote for pressure sore avoidance, the orthoses were worn at least eight hours daily by all participants.

Figure 1. a) Front view of UCBL orthosis **b)** Rear view of UCBL orthosis **c)** Side view of UCBL orthosis

University of California at Berkeley Laboratory (UCBL)

Kinesio taping was applied in order to reverse the deformity mechanism. A standard 5-cm BBtape© was used for Group 1. The first strip, in varying lengths according to the patient's foot size, was applied from the lateral malleolus, around the calcaneus, with a 100% stretch, up to the medial tibia. The strip was applied to the skin on the supine position. The second strip was applied on the projection of the tibialis posterior muscle, starting from the origin of the muscle with a 50% stretch, up to the insertion of the tendon on the navicula. The third strip was applied from the longitudinal arch with a 100% stretch to the distal tibia, which lied parallel to the first strip, trying to restore the flattened footpad. After application, the physician warmed the Kinesio tape by rubbing his hand from the starting point to the end point in order to maximize its adhesion (Figure 2).

Figure 2. First tapping application. The figure **a, b, c, d** show how to application of tapping for flatfoot.

Foot pronation was assessed post-taping, during follow-ups, and at the treatment's end, with participants in a relaxed standing position (Figure 3-4).

Figure 3. Second tapping application. Figure **a** and **b** show how to application of tapping for flatfoot.

The order of application was shown respectively.

Figure 4. Third tapping application. Figure a and b show how to application of tapping for flatfoot. Figure c shows combination of the UCBL orthosis and Kinesio Tape.

Treatment cessation criteria included symptom regression, normalized talus-calcaneus angle, and improved AOFAS scores.

Statistical analysis was conducted using NCSS 2007 software, employing descriptive statistics, independent samples t-tests, and a significance level of $p<0.05$. The analysis was carried out with a 95% confidence interval.

RESULTS

The average duration of follow-up was 28.3 months (with a final range of 25.1 to 47.4 months) for Group 1 and 27.3 months (with a final range of 23.4 to 49.0 months) for Group 2. A two-sample t-test revealed no significant disparity in follow-up length between the two groups. Based on the available data, there were no statistically significant distinctions in age and gender between the two groups ($p>0.05$) (Table 1).

The orthosis treatment notably improved the intertarsal relationship in the sagittal plane and diminishing subtalar subluxation during weight-bearing. Allergic reactions developed in 16% of patients (n=8) using KT.

No statistically significant variation was identified in terms of baseline AOFAS scores between the two groups ($p>0.05$). However, at the sixth-week follow-up, the AOFAS scores of Group 1 were considerably higher than those of Group 2 (Table 2).

Radiographic Assessments

Patients' X-rays were evaluated before treatment, at the 6th and 12th month follow-ups. The inter-rater reliability coefficient for the two radiography assessors ranged from 0.92 to 0.95 for all five measurements.

An increased CPA post-intervention indicated deformity improvement; a larger CPA denoted less plantar flexion of the hindfoot. Both groups demonstrated significant enhancement in CPA between pretreatment and post-treatment 6th month measurements.

For both the left and right sides, baseline, 6th month, and 12th month lateral CPAs exhibited no statistically significant differences between the two groups. Similarly, no significant variation was observed in AP TCA measurements between the two groups for the left and right sides prior to treatment and at the 6th and 12th month follow-ups ($p>0.05$). The baseline and 6th month follow-up measurements for lateral TCA on both the right and left sides displayed no statistically significant changes ($p>0.05$). Although the lateral TCA results for the right side at the 12th month follow-up did not reveal significant differences ($p>0.05$), a significant difference in favor of Group 2 emerged for the left side ($p<0.05$). In Group 2, the mean lateral TCA measured 28.00±5.69 degrees, whereas in Group 1, it measured 24.00±5.83 degrees (Table 3).

Table III: Evaluation of the talocalcaneal angle, talo-first metatarsal, calcaneal pitch and talonavicular angles.

		Right side		p*	Left side	
		Group 1 (n=27) Mean±SD	Group 2 (n=23) Mean±SD		Group 1 (n=27) Mean±SD	Group 2 (n=23) Mean±SD
TCA AP	Baseline	42.00±5.83	40.00±5.69	0.228	42.00±5.83	41.00±5.69
	6th month	38.00±5.83	38.00±5.69	1.000	38.00±5.83	39.00±5.69
	12th month	35.00±5.83	36.00±5.69	0.544	35.00±5.83	37.00±5.69
TCA Lateral	Baseline	34.00±5.83	32.00±5.69	0.228	32.00±5.83	32.00±5.69
	6th month	30.00±5.83	30.00±5.69	1.000	28.00±5.83	30.00±5.83
	12th month	26.00±5.83	28.00±5.69	0.228	24.00±5.83	28.00±5.69
TFM AP	Baseline	18.00±5.83	17.00±5.69	0.544	18.00±5.83	17.00±5.69
	6th month	16.00±5.83	16.00±5.69	1.000	16.00±5.83	16.00±5.69
	12th month	14.00±5.83	15.00±5.69	0.544	14.00±5.83	15.00±5.69
TFMA Lateral	Baseline	15.00±5.83	16.00±5.69	0.544	15.00±5.83	16.00±5.69
	6th month	13.00±5.83	15.00±5.69	0.228	13.00±5.83	15.00±5.69
	12th month	10.00±5.83	14.00±5.69	0.018	10.00±5.83	14.00±5.69
CPA Lateral	Baseline	11.00±5.83	12.00±5.68	0.544	11.00±5.83	12.00±5.68
	6th month	14.00±5.83	13.00±5.69	0.544	14.00±5.83	13.00±5.69
	12th month	16.00±5.83	15.00±5.69	0.544	16.00±5.83	15.00±5.69
TNA	Baseline	45.00±5.83	45.00±5.69	1.000	45.00±5.83	45.00±5.69
	6th month	43.00±5.83	44.00±5.69	0.544	43.00±5.83	44.00±5.69
	12th month	42.00±5.83	43.00±5.69	0.544	42.00±5.83	43.00±5.69

**Student's t-test*

AP: anteroposterior, CPA: calcaneal pitch angle, TCA: talocalcaneal angle, TFMA: talo-first metatarsal angle, TNA: talonavicular angle.

Significant p values are written in bold.

The right and left TFMA on AP radiographs showed no significant differences between the two groups at baseline, 6th month, and 12th month follow-up measurements ($p>0.05$). The right and left TFMA on lateral radiographs displayed no significant differences between baseline and 6th month measurements ($p>0.05$). However, the 12th month follow-up measurements for both right and left TFMAs were found to be significantly different between Group 1 and Group 2 ($p<0.05$). In Group 2, the mean lateral TFMA measured 14.00±5.69 degrees, while in Group 1, it measured 10.00±5.83 degrees (Table 3).

Measurements of the TNA at baseline, 6th month, and 12th month follow-ups exhibited no statistically significant differences ($p>0.05$) (Table 3).

DISCUSSION

Flatfoot is often observed in children aged 3 to 6 years and prompts many parents to seek guidance from orthopedic specialists. Mild-to-moderate deformity characterizes the most frequent type of SFPP. The prevalence of SFPP is 44% among children aged 3 to 6 years, drops to 24% in those over 6 years[9]. While usually idiopathic, SFPP can also stem from dystrophic, traumatic, neurological, or other causes. Pathological or rigid flatfoot arises from conditions like congenital coalition, vertical talus,intertarsal joint arthritis and post-traumatic structural abnormalities, its prevalence is nearly <1%. The condition is linked to reduced athletic and daily activity performance, as well as morbidity[13].

This study delved into the efficacy of using KT in conjunction with UCBL foot orthosis for treating SFPP in comparison to using the orthosis alone.

Our findings propose that KT effectively mitigates pronation and enhances the AOFAS score.

In-shoe orthoses provide support to the foot's plantar surface and stabilize its arch. Notably, children wearing closed-toe shoes before the age of 6 or switching from sandals or slippers tend to have a higher flatfoot deformity prevalence[14]. On the other hand, factors like obesity and ligament laxity emerge as risks during adulthood. Timely intervention yields satisfactory outcomes[14,15]. Ferri et al. emphasized that differences between pes planus and normal feet are more evident when bearing weight[16].

Among various measures, the forefoot arch angle significantly distinguishes between pes planus patients and normal individuals. Hence, forefoot arch angle proves a valuable gauge for diagnosing SFPP and assessing the deformity using imaging techniques[16].

Historically, flatfoot has been treated with corrective footwear or arch supports, yet the efficacy of orthoses remains disputed. A study by Staheli et al. raised questions about the effectiveness of these treatments, suggesting that flatfoot in early childhood is normal and spontaneously resolves without intervention[17]. While some authors argue that orthoses don't influence abnormal foot arch development or natural gait progression, others report substantial radiographic improvements with customized flexible orthoses[18].

Crucially, the alignment of the talus during ankle movement is pivotal for weight distribution through the heel and forefoot. Increased talar inclination triggers hindfoot pronation. Talar inclination can be measured using the lateral TFMA and is linked to a 2.41-fold increase in symptomatic risk[19]. In this study, both groups experienced a significant lateral TFMA enhancement following orthosis treatment. Group 1's AOFAS midoot and forefoot scores improved due to decreased talar inclination and improved arch cavus during foot development.

While the calcaneal pitch angle isn't a robust indicator for flatfoot symptom risk, it notably improved post-orthosis treatment in this study[20]. Medial arch support influences pes cavus deformity and hindfoot alignment, with improved calcaneal pitch angle contributing to pain relief.

The significance of the TCA in identifying SFPP remains unclear[21]. However, the effect of orthosis use on TCA in SFPP patients is substantial[22]. The AP TCA's unreliability stems from its weak correlation with disease severity[21].

Although pain score improvement has been linked to the lateral TCA, arch configuration poorly correlates with SFPP pain scores[23]. Therefore, evaluating SFPP using the lateral TCA seems more sensible. Nevertheless, Kanatlı et al. found no correlation between calcaneal pitch, lateral TCA, and arch index[24]. A functional foot orthosis can enhance step symmetry, length, and width.

The current study established that orthosis treatment improved intertarsal relations solely in the sagittal plane, delivering pain relief through hindfoot alignment enhancement and reduced subtalar subluxation during weight-bearing.

Furthermore, the study showed that orthosis treatment notably enhanced AOFAS midfoot and forefoot scores. Increased lateral TCA improved AOFAS hindfoot scores, but increased CPA had an adverse impact. Over time, AOFAS forefoot scores,hindfoot scores tend to improve due to factors like enhanced muscle strength and joint flexibility. Notably, CPA and lateral TCA showed strong correlation with AOFAS hindfoot scores.

The cotton, adhesive, latex-free, elastic nature of Kinesio tape differentiates it from standard

athletic tape, being more porous and water-resistant. Patients can wear it for several days after application[25]. Although the tapes were changed every three days in this study, with a one-day hygiene break, 16% of participants experienced allergic reactions.

Mereday et al. found that the UCBL orthosis helps restore proper calcaneus positioning in flexible flatfoot deformity[22]. The UCBL orthotic device effectively brought some arch and hindfoot parameters closer to their non-pathologic values, partially restoring midfoot bone alignment by supporting the midfoot bones' contours. Kogler et al. suggested that effective longitudinal arch support requires the orthosis's medial surface to support the arch's apical bones[26]. The UCBL also assisted calcaneus inversion with respect to the tibia, aiding hindfoot restoration to a more erect, healthy alignment. Correct calcaneus positioning is deemed crucial in treating flatfoot. The UCBL also dorsiflexed the talus at the ankle joint, moving it to a more normal position, though not entirely reversing the flatfoot configuration. Proper talus alignment in plantar/dorsiflexion is vital for even weight distribution, as improper alignment leads to undue stress on medial calcaneal ligaments and tarsal articulations[22].

KT's impact on function, pain, and range of motion is subject to debate. The present study sheds light on the effect of additional KT treatment in SFPP compared to the UCBL-only group. Several hypotheses emerge to explain KT's effectiveness, with tension generated by KT being a key distinction between the groups.

It's plausible that KT-induced tension increased neural feedback during walking and standing, bolstering balance. Tactile input can reshape motor control by altering the central nervous system's excitability[27]. Applying tape with tension along muscle fibers might boost underlying muscle strength. However, some studies suggest that taping's influence on muscle activity, as measured by electromyography or isokinetic dynamometer, is negligible. Tactile input could stimulate cutaneous mechanoreceptors enough to enhance muscle excitability, though KT might not provide sufficient muscle power enhancement[28].

Greater muscle excitability in the anterior tibia could counter excessive pronation and navicular inclination, thereby stabilizing the ankle in the posteromedial and medial direction[29].

Orthoses use for SFPP may lead to various complications. Orthoses typically need to be rigid or semi-rigid for proper tarsal bone alignment, but this can increase pressure on the tarsal bulge, decreasing treatment adherence. Stretched KT aids calcaneal valgus improvement, heightens the arch, and reduces talar head subluxation.

CONCLUSION

To summarize, our study's findings indicate statistically significant impacts of KT on postural control, albeit with limited outcomes. The results highlight that Group 1 exhibited significant symptom improvement in pes planus. The application of KT has enhanced orthosis effectiveness, resulting in improved AOFAS scores and mitigated complications associated with the use of orthosis alone. The necessity for more extensive investigations involving larger patient groups cannot be overlooked. Further research holds the potential to enhance empirical understanding of KT's utility and its potential to prevent deformities and functional limitations linked to SFPP

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