Associations of Intracompartmental Leg Pressures and Radiographic Findings in Congenital Talipes Equinovarus

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The etiopathogenesis of congenital talipes equinovarus remains mysterious. The authors investigated the role of increased intracompartmental leg pressures as a causal relationship with this deformity by measuring the pressures in 25 children aged between 6 months and 1 year with unilateral talipes equinivarus before surgical release. The deep posterior intracompartmental pressure in the leg with talipes equinovarus was greater than the other compartments, and the deep and superficial posterior intracompartmental pressures were also significantly higher than those of the contralateral normal sides ($p < 0.05$). There were linear correlations between the posterior intracompartmental pressure of affected legs and the Kite index, tibiocalcaneal angle and talo-first metatarsal angle of the affected legs. Deep posterior intracompartmental pressure is a strong predictor of abnormality in the Kite index. The present study showed a probable causal relationship between increased deep posterior intracompartmental pressure and etiopathogenesis of talipes equinovarus.

Keywords: *Compartmental pressure, Talipes equinovarus*

J Med Assoc Thai 2005; 88(5): 682-5
Full text. e-Journal: *http://www.medassocthai.org/journal*

Congenital talipes equinovarus or club foot is a common deformity in children, in which the incidence ranges from 0.39 per 1,000 among a Chinese population to 6.8 per 1000 among Polynesians[3]. There is still debate on the etiopathology of congenital talipes equinovarus. Many theories have been proposed for the cause of this deformity including genetic factor[22], primary germ cell defects[2], vascular anomalies[2,15], soft tissue factors[4,9,10,19,26], intrauterine factors[5,21] and myogenic factors[1,6,10,12,17]. It is known that most children with club foot also have calf muscle atrophy[3,17], which does not resolve after the treatment. There might, thus, be an association between muscle pathology and the deformity. Also, patients having untreatable compartmental syndrome of the deep posterior compartments of the leg will often have an equinovarus deformity similar to club foot. To the authors' knowledge, there have been no previous studies reporting the association between increased intracompartmental pressures and etiopathogenesis club foot. The objectives of the present study were to compare the intracompartmental pressures between legs with club feet with the contralateral normal sides, and also examine the correlations between the intracompartmental pressures and the radiographic findings.

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Material and Method

In the present study, 25 infants (15 males and 10 females) with unilateral idiopathic resistant club foot aged between 6 months and 1 year were included. All patients were initially treated by manipulation and casting once a week in the first month and then every two weeks for two more months. Manipulation was followed by the Ponseti technique. All feet had failed to correct after serial casting over a minimum of 3 months. Surgical correction was done between 6 months and 1 year of age. Preoperative evaluation included radiographic and intracompartmental pressure measurements. Radiographic evaluations included both anterior-posterior and lateral projection films to determine the Kite index, tibio-calcaneal angle

Table 1. Comparison of radiographic parameters and intracompartmental pressures between normal and club feet legs (n = 25)

Parameter	Normal leg (Mean, SD)	Club foot leg (Mean, SD)	p-value
Kite-index	45.0 (4.5)	29.2 (2.0)	0.002*
Tibio- calcaneal angle	6.5 (6.9)	-35.0 (2.3)	0.001*
Talo-first metatarsal angle	12.0 (3.6)	-51.4 (3.6)	0.000*
Deep posterior -compartmental pressure	2.0 (1.2)	8.7 (5.1)	0.000*
Superficial posterior -compartmental pressure	1.9 (2.1)	5.3 (4.3)	0.000*
Anterior compartmental -pressure	1.2 (1.0)	1.3 (1.5)	0.623
Anterolateral -compartmental pressure	1.2 (1.5)	1.3 (1.5)	0.559

* Statistically significant

and talo-first metatarsal angle of both sides. All radiographic parameters were measured twice by one observer before the operation. The protocol was approved by the Ethical Committee of the Faculty.

For the intracompartmental measurements, the children were given both general anesthesia and caudal block. No tourniquet was applied before the measurement. The observer was blinded for the result of the radiographic measurement. All four compartments of both sides were measured twice with a Stic catheter (Stryker, Mississauge, Ontario, Canada). The landmark for needle insertion is the mid section of the leg. Confirming the needle location was done via passively movement of the muscles in that compartment before measurement. Measure was performed on the normal side first. The first compartment to be measured was deep posterior, followed by the superficial posterior and anterolateral compartment. The anterior compartment was measured last.

Statistical analysis

All descriptive properties were analyzed statistically, and compared among parameters using either the paired t-test or multiple linear regression analysis. Pearson's correlation coefficient was used for correlation between radiographic parameters and intracompartmental pressures. Equation of predictors was determined through the stepwise method in multiple regression analysis. A p-value ≤ 0.05 was considered to indicate statistically significant.

Results

There were 25 patients with a mean age at the time of surgery of 9.3 months. The radiographic measurements of legs having club feet showed abnormalities in the Kite index, tibio-calcaneal angle and talo-first metatarsal angle. The average intracompartmental leg pressure of the normal side was 1.4 mmHg (range 0-5), while that of the club foot legs was 4.2 mmHg (range 0-15). Intracompartmental pressures in the deep posterior and superficial posterior compartments of the club foot legs were significantly higher than those of the contralateral normal side, while the pressures in the anterior and anterolateral compartments showed no difference (Table 1). Intracompartmental pressure in the deep posterior compartment in any club foot leg was higher than the pressure in the other compartments (Table 2).

Table 2. Intracompartmental pressure of each compartment in legs with club feet as the independent variables in the final model, using multiple linear regression analysis

Compartment	Coefficient	p-value	95%CI
Deep posterior	1	-	-
Superficial posterior	-2.152	0.002*	-0.349 - -0.808
Anterior	-5.543	0.000*	-6.887 - -4.199
Anterolateral	-5.586	0.000*	-6.930 - -4.243

* Statistically significant

Linear correlations between the radiographic parameters and the amount of deep posterior intracompartmental pressures in the club foot side were found, eg, between kite index, tibio-calcaneal angle and talo-first metatarsal angle and the deep posterior compartmental pressure. However, there were no significant correlations between these radiographic parameters and the superficial posterior intracompartmental pressures. There was also a linear correlation between the deep and superficial intracompartmental pressure in the club foot legs (Table 3). From the stepwise method in the multiple linear regression analysis, the only significant factor that could predict the abnormality in the Kite index was the deep posterior intracompartmental pressure, defined by equation as

Kite index = 34.801-0.153 (deep posterior intracompartmental pressure)

Table 3. Correlations between radiographic parameters and leg intracompartmental pressures, using Pearson's correlation coefficient

Parameters	Kite index	T-C angle	T-M angle	DPP	SP	AP	ALP
Kite index	1.000	-	-	-	-	-	-
T-C angle	-0.537 (0.001)*	1.000	-	-	-	-	-
T-M angle	-0.543 (0.001)*	0.613 (0.000)*	1.000	-	-	-	-
DPP	-0.388 (0.007)*	0.284 (0.055)*	0.518 (0.000)*	1.000	-	-	-
SP	-0.170 (0.258)	0.454 (0.041)	0.138 (0.345)	0.695 (0.000)*	1.000	-	-
AP	-0.274 (0.065)	0.132 (0.380)	0.119 (0.430)	0.242 (0.103)	0.263 (0.077)	1.000	-
ALP	0.087 (0.561)	-0.024 (0.883)	0.144 (0.339)	-0.192 (0.199)	0.02 (0.87)	0.297 (0.044)	1.000

( ) = p- value
T-C angle = Tibio-calcaneal angle, T-M angle = Talo-first metatarsal angle
DPP = Deep posterior compartmental pressure, SP = Superficial posterior compartmental pressure
AP = Anterior compartmental pressure, ALP = Anterolateral compartmental pressure

Discussion

Idiopathic congenital club foot is probably the most common pediatric orthopaedic problem. Despite having been first reported in 1800. However, it's etiology remains unclear. The present study proposed a new factor to the ethiopathogenesis of club foot, namely the increased pressure in posterior compartment of the leg during intra-uterine development might cause or at least be associated with this deformity. Increased intracompartmental pressure, especially in the deep posterior compartment, may result in contracture of the tibialis posterior, flexor hallucis longus and flexor digitorum profundus, causing a traction-type force on the posteromedial structure of the ankle, which could cause the navicular bone to subluxate medially from the talonavicular joint. As the talus also articulates with the calcaneous in a triple joint complex, both the subtalar joint and the calcaneocuboid joint would also be affected. Bony dysplasia of the talus can also be explained by prolonged abnormal pressure, resulting in medial and plantar deviation. Calf atrophy, which occurs in almost all cases of club feet, might be explained by decreased muscle belly.

Radiographic parameters, including the Kite index, tibio-calcaneal angle and talo-first metatarsal angle, correlated well with the amount of intracompartmental pressure expressing dose-response relationship indicating that there could be a causal relationship. Whether the foot, through being kept in a prolonged abnormal position, can develop intracompartmental pressure elevation is a question that needs further study.

Normal intracompartmental pressure of the legs of children has not been studied before. In the present study, the pressure in the non-affected leg is lower than previously reported[18-20]. This might be associated with the volume of the muscle fibers, the effect of anesthesia, or the type of instrument[21]. The Stic catheter is a reliable and easy-to-use instrument with the accuracy of 1 mm[22].

The intracompartmental pressure measurement in a club foot might have benefit in terms of prediction of the recurrence after treatment, but further prospective study needs to be done to confirm this.

The main limitation of the study is a lack of temporal relationship in the cross-sectional design, so the authors could not tell if the increased intracompartmental pressures are really a cause or effect of a club foot development. The reliability of the radiographically determined parameters of club foot may be a limitation, as imcomplete ossification makes it difficult to accurately measure angles such as the Kite index, tibio-calcaneal and talo-first metatarsal angle. However, in the present study, the authors minimized this variability by having it made by only one observer who was blinded to the radiographic results.

In conclusion, the authors found a significant increase in the intracompartmental pressure of the posterior compartment of the leg with club foot compared to the normal leg of the same patient. The degree of pressure elevation in this compartment correlated well with abnormalities in the radiographic parameters. The authors propose that increased pressure in the posterior compartment of a leg might be associated with etiopathogenesis of club foot.

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ความสัมพันธ์ระหว่างความดันในช่องกล้ามเนื้อขากับความผิดปกติของภาพถ่ายรังสีในผู้ป่วยเท้าปุก

บุญสิน บูรณะพาณิชย์กิจ, วิภาวรรณ ลีลาสำราญ

สาเหตุของโรคเท้าปุกยังไม่เป็นที่ทราบแน่ชัด ผู้วิจัยศึกษาความสัมพันธ์การเพิ่มขึ้นของความดันในช่องกล้ามเนื้อขาในผู้ป่วยเด็กเท้าปุก 25 ราย อายุระหว่าง 6 เดือนถึง 1 ปีที่เข้ารับการผ่าตัดพบว่ามีการเพิ่มขึ้นของความดันในช่องกล้ามเนื้อช่องลึกส่วนหลังของขา (deep posterior intracompartmental pressure) อย่างมีนัยสำคัญเมื่อเทียบกับความดันในช่องกล้ามเนื้ออื่น ๆ ความดันในช่องกล้ามเนื้อส่วนหลังของขา (posterior intracompartmental pressure) ของเด็กเท้าปุก มีค่าสูงกว่าความดันในช่องกล้ามเนื้อเดียวกันด้านตรงข้ามอย่างมีนัยสำคัญ ($p < 0.05$) พบความสัมพันธ์เชิงเส้นตรง (linear correlation) ระหว่างความดันในช่องกล้ามเนื้อส่วนหลังกับค่าดัชนีของ Kite มุม tibio-calcaneal และมุม talo-first metatarsal ในขาที่เป็นเท้าปุก ความดันในช่องกล้ามเนื้อช่องลึกส่วนหลังเป็นตัวบ่งชี้ (predictor) ต่อความผิดปกติของค่าดัชนี Kite การศึกษานี้แสดงถึงความสัมพันธ์การเพิ่มขึ้นของความดันในช่องกล้ามเนื้อขาในผู้ป่วยเท้าปุก