The effect of distal first metatarsal osteotomy on the forefoot conditions at hallux valgus surgery

PhD thesis

Péter Kellermann MD.

University of Szeged
Albert Szent-Györgyi Clinical Center
Department of Orthopaedics

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VI. Tóth K, Boda K, **Kellermann P,** Zadravecz Gy, Korcsmár J: Clinical and gait analysis of 171 unilateral calcaneal fractures. Clin Biomech 1997;12:S17-18.

VII. Tóth K, **Kellermann P**, Boda K, Bertalan M, Fejes I, Mészáros T: Foot pressure distribution in rheumatoid arthritis. Clin. Biomech 1999;14:562.

VIII. Tóth K, **Kellermann P**, Boda K, Horváth A, Simonka J: Clinical and gait analysis of 165 ankle fractures. Clin. Biomech 1999;14:563.

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Abbreviations used in the study

AOFAS	American Orthopaedic Foot and Ankle Surgeons
HV	hallux valgus
HVA	hallux valgus angle
IMA	intermetatarsal angle
LT	Lindgren-Turan
MTP	metatarso-phalangeal
ROM	range of movement
SD	standard deviation

TABLE OF CONTENT

1. Introduction ... 3
    1.1. Justification of the decision on the topic of the study ... 4
2. Review of the literature ... 5
    2.1. Foot function and normal gait mechanics ... 5
    2.2. The first metatarso-phalangeal joint ... 6
    2.3. Aetiology of hallux valgus ... 7
        2.3.1. Biomechanics ... 7
        2.3.2. Shoewear ... 8
        2.3.3. Heredity ... 8
        2.3.4. Gender ... 8
    2.4. Diagnosis of hallux valgus ... 8
        2.4.1. Physical signs and symptoms, examination ... 8
        2.4.2. Radiological examination ... 9
        2.4.3. Pedography ... 12
            2.4.3.1. Short history ... 12
            2.4.3.2. The structure of the pedography device ... 13
            2.4.3.3. The process of the examination ... 13
            2.4.3.4. Preparation of the raw data for statistical analysis ... 13
    2.5. Treatment of hallux valgus ... 14
        2.5.1. Conservative treatment ... 14
        2.5.2. Operative treatment ... 14
            2.5.2.1. The effect of the surgical technique of the first metatarsal osteotomy on the forefoot anatomy ... 15
3. Hypotheses ... 17
4. Patients and methods ... 18
    4.1. Patients ... 18
        4.1.1. Department of Orthopaedics, County Hospital of Miskolc ... 18
        4.1.2. Department of Orthopaedics, Medical University of Szeged ... 18
    4.2. Surgical method and indication criteria ... 19
        4.2.1. Surgical method ... 19
        4.2.2. Indication criteria ... 20
    4.3. Examination methods ... 20
        4.3.1. Status recording sheets ... 20
        4.3.2. Radiological evaluation ... 21
        4.3.3. Pedography ... 24
    4.4. Statistical analysis ... 25
5. Results ... 26
    5.1. Retrospective analysis of the Lindgren-Turan and Wu procedures performed in 1994 to 1998 in Miskolc ... 26
    5.2. Prospective analysis of the Lindgren-Turan procedures performed in 1991 to 1994 in Szeged ... 28
6. Discussion ... 32
7. Conclusion ... 37
8. References ... 38

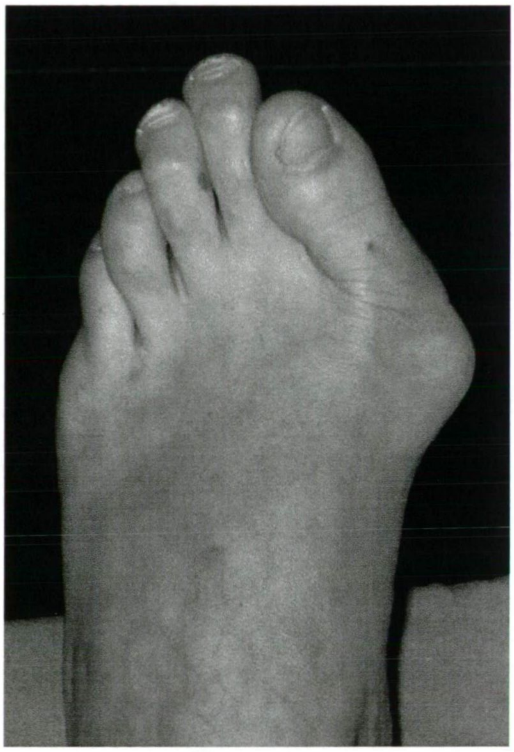
A. Appendix
Appendix 1: Pre- and postoperative questionnaire for hallux valgus patients (1991 to 1994) A-1
Appendix 2: Pre- and postop status sheet of hallux valgus patients in the period of 1994 to 1998 ..... A-4
Appendix 3: AOFAS Hallux Metatarsophalangeal-Interphalangeal Scale A-5

B. Full text of the articles involved into this study
I. Kellermann P, Tóth K: Lindgren műtéteink hosszú távú eredményei. Accepted for publication in Magyar Traumatol Ortop B-1
II. Tóth K, Huszanyik I, Kellermann P, Boda K, Róde L: The effect of first ray shortening in the development of metatarsalgia in the second through fourth rays after metatarsal osteotomy. Foot Ankle Int 2007; 28:61-63. ..... B-11
III. Tóth K, Huszanyik I, Boda K, Róde L, Kellermann P: The influence of the length of the first metatarsal on transfer metatarsalgia after Wu's osteotomy. Accepted for publication in Foot Ankle Int B-19

1. INTRODUCTION

Hallux valgus (HV, Fig. 1.) occurs when the great toe is deviated laterally and the first metatarsal is deviated medially (14). This malformation is often accompanied by a slight rotation of the great toe around its longitudinal axis. This compound deformity, by definition, should be called as hallux abducto-valgus; however, the literature tends to use generally the term "hallux valgus" instead.

Figure 1.
Hallux valgus (bunion)



A hallux valgus angle (HVA) is the angle between the longitudinal axis of the first metatarsal and that of the proximal phalanx of the great toe. A first-second intermetatarsal angle (IMA) is defined as the angle between the longitudinal axis of the first and second metatarsals. Although there isn't any strict consensus on the boundary between normal and abnormal values, a HVA greater than 15 degrees and a first-second IMA greater than 9 degrees are most commonly considered as abnormal (48, 49).

As the border between normal and abnormal HVA is not definitive, the prevalence of HV cannot be accurately established. HV is considered to be more frequent at elder age and females; at these populations its occurrence is estimated as over 30 percent (71).

The aetiology of the HV is still unknown; however, numerous theories are available. Non-fitting shoewear is considered as a major cause, which theory is supported by the high prevalence of HV in women (20, 21) and a low prevalence at people not wearing shoes (15). A poor function of the joints of the foot is also considered as a contributing factor of the HV deformity (48).

At the first diagnosis of the HV deformity, a conservative therapy is usually attempted. A surgical procedure is indicated, when there is pain around the first metatarso-phalangeal (MTP) joint, when foot function is affected, or when the deformity causes difficulties in the usage of a regular shoewear.

HV surgery is one of the most common orthopaedic procedures. Numerous techniques have been described for the correction of HV and increased first-second IMA. For a mild to moderate HV deformity, a distal (subcapital) osteotomy of the first metatarsal is a widely used method. Following the surgical correction of the HVA and first-second IMA, undesired effects on the forefoot may develop, resulting in a poorer outcome.

1.1. Justification of the decision on the topic of the study

The purpose of the present study is to explore, how the operating technique of the distal first metatarsal osteotomy influences the forefoot conditions concerning pain, function and cosmetics. This topic holds an importance through the popularity of the distal osteotomies in hallux valgus surgery all over the world. Any proven conclusion about the possibility to decrease the number and magnitude of late complaints after the procedure may be beneficial for the surgeon to decide, which technique and how to use, and which technique to avoid.

2. REVIEW OF THE LITERATURE

2.1. Foot function and normal gait mechanics

The foot provides two important, but quite different functions during ambulation: it adapts the foot to the ground softly during the heel strike, and then it acts as a rigid lever to hold the body weight (68).

The gait cycle is divided into two main phases: the stance phase and the swing phase; the former can be divided into three phases: a contact phase, a midstance phase and a propulsive phase (50).

The contact phase of the stance phase begins with the heel strike and terminates with the forefoot loading. During the contact phase the foot is in a slight supination at the subtalar joint, which turns into a pronation when the heel strike occurs. The tibialis posterior muscle contracts, which decelerates the pronation movement, hence, the foot absorbs part of the heel strike force. The knee is in a slightly bended position, which provides another powerful shock absorber effect. The midtarsal joint - which is the unit of two anatomically different, but functionally united joints: the talonavicular and the calcaneocuboid joint - is loose and unstable when the foot is in pronation, so at the contact phase it becomes loose, preparing the foot for the adaptation to the terrain (50).

The midstance phase begins with the opposite side foot toe-off, and terminates with the heel lift. During this phase the contralateral limb is in its swing phase, so the whole body weight is supported by one limb. As the centre of the body weight slides anteriorly, the leg rotates externally (68). The talus abducts, causing the supination of the subtalar joint. This results in a decrease of the range of movement (ROM) in the midtarsal joint, which increases the stability of this joint (50).

The propulsive phase begins when the heel lifts, and terminates with the toe-off. This phase requires the highest level of stability, as the body weight is concentrated on the metatarsal heads. At this phase, the plantar fascia winds itself around the metatarsal heads, this way it acts like a pre-stretched bowstring. It pulls the calcaneus towards the metatarsal heads (68). The body weight is now shifted onto the midfoot and the medial side of the forefoot. The great toe dorsiflexes, which is followed by a strong contraction of the flexor hallucis longus, increasing the resistance of the forefoot against reaction forces.

2.2. The first metatarso-phalangeal joint

The first MTP joint consists of the distal articular surface of the first metatarsal, and the proximal articular surface of the proximal phalanx of the great toe. The two sesamoids and their counteracting articular surface on the plantar aspect of the first metatarsal head are also involved into the unit of the first MTP joint.

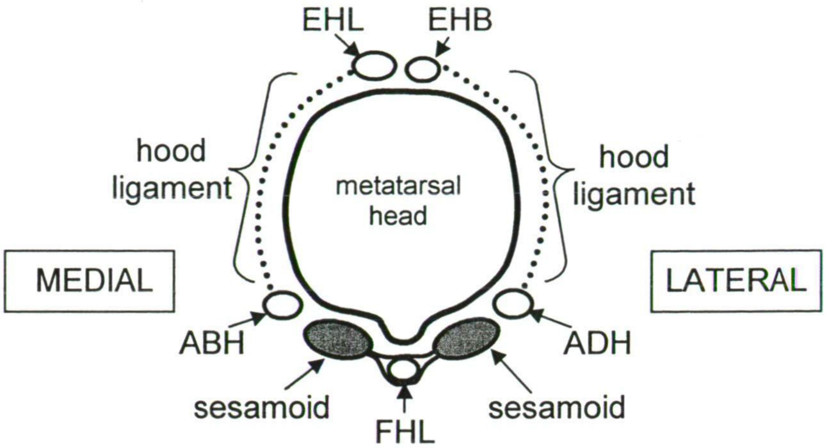
The first MTP joint has a motion in two axes: the transverse axis provides the plantarflexion and dorsiflexion, while the vertical axis provides the abduction and adduction of the great toe.

The most valuable motion of the hallux is dorsiflexion. The minimum required ROM of dorsiflexion for a normal gait is approximately 70-75 degrees, as the tibia is tilted forward at about 45 degrees, and the upper ankle joint becomes into another 20-25 degrees of plantarflexion at the moment of the toe-off (50).

During the propulsive phase, while the heel lifts, the second to fifth metatarsals roll forward over the soft tissues of the sole beneath them, while the first metatarsal glides instead on the two sesamoids. This results in a fallback of the first metatarsal related to the other ones. The first metatarsal therefore plantarflexes, forming a stable support for the forefoot during the toe-off.

The muscles that provide the movements of the first MTP joint can be divided into four groups (Fig. 2.). 1.: The extensor hallucis longus and brevis pass the joint dorsally above the centre of the metatarsal head, and are responsible for the dorsiflexion (extension) of the MTP joint. 2.: The plantarflexion of the joint is provided by the flexor hallucis longus and brevis. The latter divides and involves the two sesamoids, before attaching on the base of the proximal phalanx by the plantar plate. The former runs separately, plantar to the sesamoid complex. Both run beneath the centre of the metatarsal head. This central position of the extensor and flexor muscles avoids any ab- or adduction torque (50). 3.: The adductor hallucis muscle has a transverse and an oblique spindle. 4.: The abductor hallucis muscle counteracts the adductor hallucis.

Figure 2.
The position of the tendons around the first metatarsal head



EHL: extensor hallucis longus; EHB: extensor hallucis brevis; ABH: abductor hallucis; FHL: flexor hallucis longus; ADH: adductor hallucis (14)

2.3. Aetiology of hallux valgus

2.3.1. Biomechanics

The classical theory of Root states that the main causative factor of the HV is a mechanical malfunction of the first MTP joint (50). Abnormal subtalar joint pronation is the primary cause of this malfunction (29); it results in a hypermobile first metatarsal, which is responsible for the instability of the first MTP joint, through the repetitive attempts of the walker for stabilizing the hallux against the asymmetrical forces. Abnormal pronation of the subtalar joint results in an eversion of the first metatarsal and the hallux (68). The sesamoids slide laterally, so the flexor and extensor muscles leave their central position, forming a lateral (valgus) force on the great toe. The hallux then slides into valgus position (42).

When the foot is in pronated position, the peroneus longus tendon becomes relatively long, as its attachments are closer to each other than normally. The plantarflexion effect of the peroneus longus muscle on the first metatarsal is disturbed this way; the reduced extent of plantarflexion results in an increased compression force between the articular surfaces of the first MTP joint (26).

The role of a flatfoot in the development of HV is controversial. Inman supported that HV is always combined with pes planus, and that pes planus is a predisposing factor for HV (27). Other studies did not document any association between pes planus and hallux valgus (15, 33, 51).

2.3.2. Shoewear

Although the improper footwear as a contributing factor to the development of HV has not yet been properly proven, epidemiological studies on HV support this view (15). In studies analysing barefoot natives in Africa (4) or New Guinea (43) no tendency was found for HV at both genders, including elder inhabitants. A study from China compared people who wore shoes with ones who didn't. Among the ones wearing shoes, the prevalence of HV was 33%, while among the barefoot group only 2% (52).

2.3.3. Heredity

Studies on the heredity of HV indicate that some foot types seem to be susceptible for HV. Johnston found that HV is inherited as an autosomal dominant trait with incomplete penetrance (28). Wallace and Kilmartin reported in an examination where 224 nine-year-olds with evidence of HV had either a positive family history or had a mobile first metatarsal (69).

2.3.4. Gender

A much higher proportion - 85 to 90% - of female HV cases compared to male ones has been reported in several studies (9, 11, 17, 22).

2.4. Diagnosis of hallux valgus

2.4.1. Physical signs and symptoms, examination

The primary symptom of HV is pain over the medial aspect of the first MTP joint. It can be caused by pressure of an inappropriate shoewear, and can be accompanied by inflammation of the medial bursa.

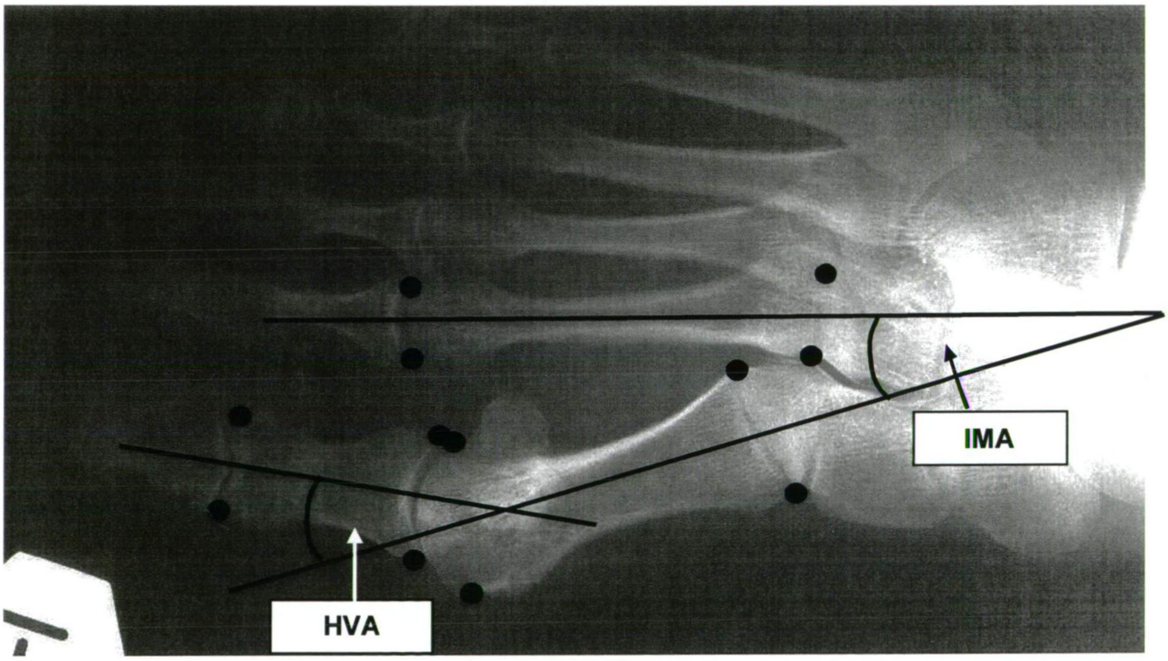
HV should be examined with the patient sitting and than standing. Load bearing (standing) may accentuate the HV deformity in a remarkable extent. The magnitude of HV deformity as well as any pronation of the great toe is recorded. The active and passive ROM of the first MTP joint is measured (54). Pain or crepitation in the first MTP joint is documented, as well as any deformities on the lesser toes. The sole is examined for any callosity or pain beneath the lesser metatarsal heads (metatarsalgia). Pes planus or equinus contracture of the ankle joint must be checked.

2.4.2. Radiological examination

A proper radiological examination of the foot consists of a dorso-plantar and a lateral view. The dorso-plantar picture is strongly recommended to be taken in a weight bearing position (14); however, the weight bearing lateral view also has a great importance. Evaluation of the radiographs includes measurement of the HVA, the first-second IMA, the distal metatarsal articulation angle, the proximal phalangeal articulation angle and the congruency of the joint cartilage surfaces. The position of the sesamoids is recorded. The first MTP joint is checked for any medial eminence or osteoarthrosis.

The **HVA** is formed by the longitudinal axis of the first metatarsal and that of the proximal phalanx; the **first-second IMA** is formed by the longitudinal axis of the first metatarsal and that of the second metatarsal (Fig. 3.).

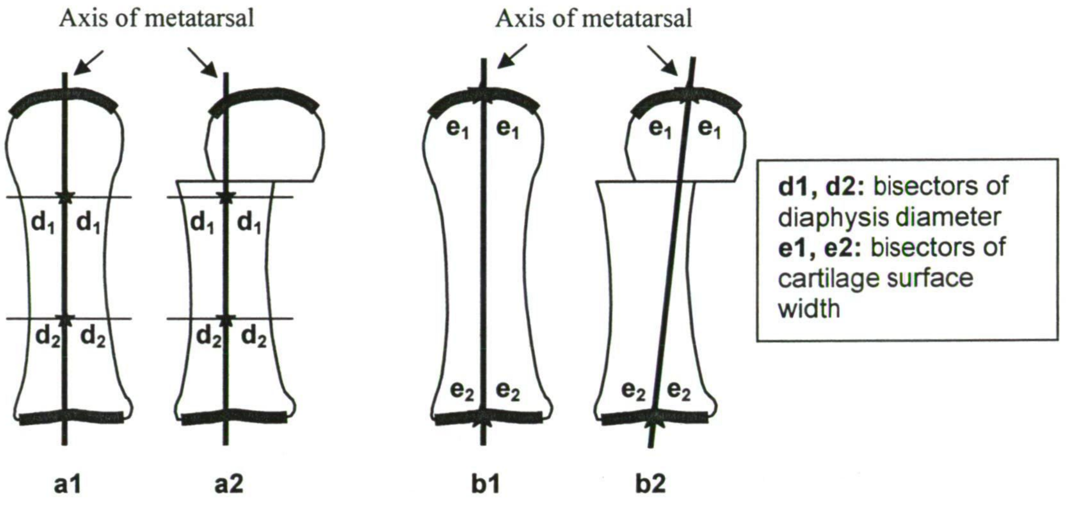
Figure 3.
Compilation of the HVA and 1-2 IMA



Dots mark the endpoints of the articular surfaces of the first and second metatarsal and those of the proximal phalanx of the great toe. HVA: hallux valgus angle; IMA: 1-2 intermetatarsal angle

The definition of the longitudinal axis of a metatarsal is crucial; the line laid onto the midpoints of the proximal as well as the distal articular surfaces of the metatarsal is highly recommended, as other methods may cause a serious misinterpretation of the measured angles (Fig. 4.).

Figure 4.
The two different methods of compilation of the longitudinal axis of a metatarsal before and after subcapital osteotomy

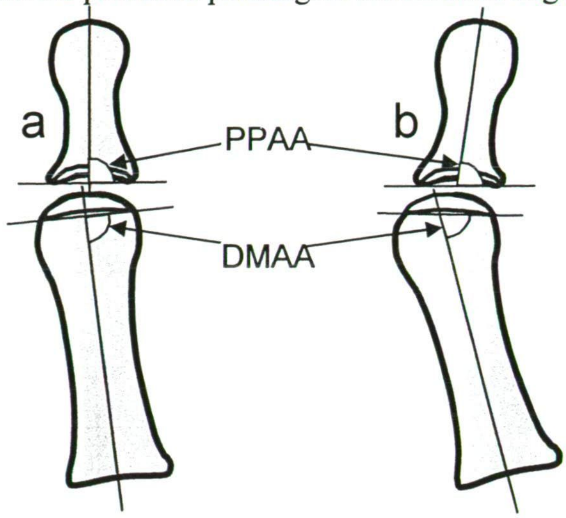


a: the longitudinal axis defined by the two bisectors of the diaphysis before (a1) and after (a2) osteotomy
b: the longitudinal axis defined by the two bisectors of the cartilage surface before (a1) and after (a2) osteotomy
Figure a2 demonstrates that the diaphyseal method may completely ignore any correction of the axis

A HVA of 15 degrees or less, and a first-second IMA of 9 degrees or less is considered as normal value as defined in the textbook of Mann and Coughlin (40).

The **distal metatarsal articulation angle** and the **proximal phalangeal articulation angle** are measured as the angles between the longitudinal axis and the line connecting the endpoints of the cartilage surface of the first metatarsal and the proximal phalanx, respectively (Fig. 5.).

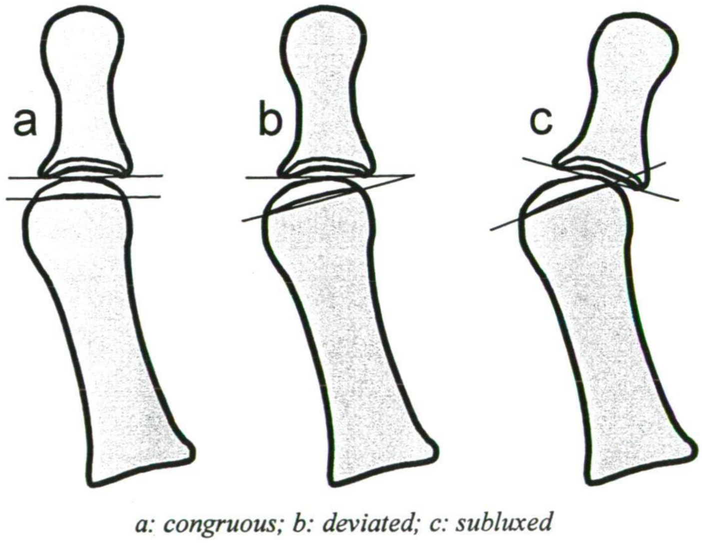
Figure 5.
The compilation of the distal metatarsal articulation angle and the proximal phalangeal articulation angle



a: DMAA and PPAA are 90 degrees; b: DMAA and PPAA deviate from 90 degrees
DMAA: distal metatarsal articulation angle; PPAA: proximal phalangeal articulation angle

The **congruency** of the joint surfaces is determined by the alignment of the lines connecting the endpoints of the joint cartilage surfaces (41). If the lines are parallel, the joint is considered as congruous; if the lines intersect outside the joint, the joint is deviated; if the lines intersect within the joint, it is considered as subluxed (Fig. 6.).

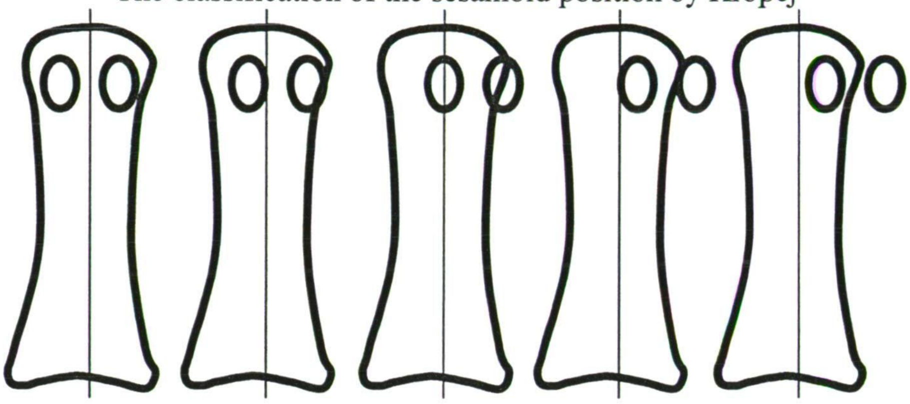
Figure 6.
The congruency of the first metatarso-phalangeal joint



a: congruous; b: deviated; c: subluxed

The **position of the sesamoids** compared to the longitudinal axis of the first metatarsal can be calculated on the AP radiogram (36, 37). In the present study, the numerical sequence of one to five as described by Kropej (36) was used (Fig. 7.).

Figure 7.
The classification of the sesamoid position by Kropej



1 2 3 4 5

1: normal situation; 2: the tibial sesamoid reaches the midline of the first metatarsal; 3: the tibial sesamoid is halved by the midline of the first metatarsal; 4: the tibial sesamoid is still in contact with the midline of the first metatarsal; 5: the tibial sesamoid is displaced laterally to the midline of the first metatarsal

2.4.3. Pedography

This method gives detailed information on the pressure conditions of the sole during walking (32). Normal foot pressure and gait dynamics parameters have been published by Bryant et al (10). Several publications on the pedographic conditions of the foot in diverse pathological changes has been introduced by our (University of Szeged, Department of Orthopaedics) pedography team: an overload of the metatarsal region when high heel is worn (57), relief of overload beneath the second-third-fourth metatarsal heads after Helal osteotomy and shortening (62), effect of lumbar disc protrusion or diabetic neuropathy on the plantar pressure distribution (60, 67), gait characteristics of patients having had ankle or calcaneal fracture (58, 59, 64), plantar pressure changes in rheumatoid arthritis (63).

2.4.3.1. Short history

The screening of the pressure conditions under the sole has started over 150 years ago. In 1853, Meyer published his theory of the three-point supporting structure of the foot, which seemed to be unwavering for many decades (45). Beely, however, found in 1882 that the main load bearing portion of the forefoot during ambulation is the area of the second and third metatarsal heads (6). In the '80-s, computerised pedographic analysers have been introduced, which gave a rapid increase in accuracy of the dynamic pressure parameters. Numerous authors found the highest pressure values beneath the second and third metatarsal heads (12, 19). Hennig claimed that the pressure beneath the different portions of the sole raises in an unequal rate at ambulation, related to postural position: the load of the second and third metatarsal heads increases in a much higher proportion than that of the remaining foot areas (25).

2.4.3.2. The structure of the pedography device

The device was manufactured by the Novel GmbH (Munich, Germany). It includes a central unit (101B) and a pressure sensitive platform (102H). The platform consists of 2736 sensors on a 190x360 mm surface (4 sensors/square cm), these provide force data with a frequency of 50/sec to the central unit. The acquired data can be evaluated by the EMED software provided by the Novel Company.

2.4.3.3. The process of the examination

We built the pressure sensitive platform into the middle of a six meter long walkway. This distance allows the patient to gain his/her normal walking speed by making four to five steps before the recorded one, which represents the main advantage of this - so called - mid-gait method, as walking speed plays a remarkable roll in the pedographic recording. The influence of walking speed on the pressure and time conditions of the foot has been described (65). Some authors prefer the one-step or the two-step method (10, 49), claiming that these techniques provide a better reproducibility.

During walking along the walkway, the patient makes a step onto the platform, without slowing down, tilting, or pacing longer/shorter than his/her normal step length. Any inappropriate trial is excluded by a trained examiner, with the help of the EMED software provided; in this case the recording is repeated.

2.4.3.4. Preparation of the raw data for statistical analysis

The basic data are the force values. As the appropriate size of the sensors is given, pressure values can be easily calculated. The data are recorded continuously by a 50/sec frequency, which - besides the contact time values - allows a calculation of pressure-time integral and force-time integral values as well.

The area of the footprint can be divided into smaller sections, the data of which can be evaluated separately, and can be compared to each other, or to the identical section of footprint of another individual/group. As an example, it can be pointed out, for how long the first metatarsal head touched the ground, what proportion this time value in percent of the total pace contact time demonstrates, how much is the time shift between the heel strike and the first contact of the metatarsal head etc.

2.5. Treatment of hallux valgus

2.5.1. Conservative treatment

Conservative therapy is the first option for a HV patient (14). Non-operative treatment methods aim to reduce the HVA either by stretching the soft tissues around the first MTP joint with the use of night splints, improving muscle strength by exercises, or by resolving abnormal anatomy and function of the foot with the use of insoles (16).

Pain and bursal inflammation can be relieved by appropriate shoewear. A wider toe box or stretching of the areas of the shoe that causes pressure on the forefoot can result in a complete pain relief (14, 15).

In a randomized study, Juriansz found no significant difference according to pain among HV patients who wore night splints versus ones who did not (30).

Functional insoles (orthoses) are used to reduce the abnormal pronation of the foot during the stance phase and propulsive phase of the gait cycle. Several studies suggest that foot orthoses can restrict the pronation of the hindfoot during walking and running (5, 53). The effect of orthoses on the progression of the HV is not clearly pointed out, however.

2.5.2. Operative treatment

The number of published surgical methods for HV surgery exceeds 150 (39). This huge number indicates that no single operation itself is appropriate for each hallux valgus case. The aim of either procedure is the restoration of the foot anatomy as close to normal as possible. The theoretical options for the surgery include:

- soft tissue reconstruction around the first MTP joint
- osteotomy (of the first metatarsal, the proximal phalanx of the great toe, or the cuneiform)
- arthrodesis (of the first MTP joint or the metatarso-cuneiform joint)
- arthroplasty (resectional or prosthesis)

The indication for a particular procedure is influenced by the forefoot conditions (HVA, IMA, prominence of the medial aspect of the first metatarsal, subluxation of the sesamoids, evidence of osteoarthrosis in the first MTP joint etc.) and surgeon's preference.

A mild HV deformity (HVA less than 25 degrees) can be corrected by a distal first metatarsal osteotomy (3, 14, 38, 71, 72) with or without a soft tissue reconstruction.

At moderate level of HV (25-35 degrees) a distal first metatarsal osteotomy is favourable if the first-second IMA is close to normal. If this angle is wide, a shaft osteotomy or a proximal osteotomy of the first metatarsal is advised, together with a distal soft tissue reconstruction. In case of severe degenerative osteoarthrotic changes, an excisional arthroplasty, arthrodesis, or prosthesis implantation of the first MTP joint should be considered (14).

If the HV deformity is severe (HVA exceeds 35 degrees), proximal osteotomy of the first metatarsal is preferred. If a hypermobile metatarso-cuneiform joint is evident, an arthrodesis of this joint is needed, besides distal soft tissue procedures.

At either severity of the HV deformity, if the proximal phalangeal articulation angle deviates from normal (90 degrees), an osteotomy of the proximal phalanx is necessary in addition to the MTP joint correction.

2.5.2.1. The effect of the surgical technique of the first metatarsal osteotomy on the forefoot anatomy

If the osteotomy is performed in a single plane, the distal fragment can be shifted laterally and plantarly in a wide range. Lateral sliding ensures the decrease of the first-second IMA, and secondarily, the correction of the HVA. Plantar sliding (plantarisation) restores the dropped transversal arch by the relative elevation of the lesser metatarsal heads related to the first one (56). Besides the two-dimensional sliding, the rotational malposition (pronation) of the great toe can also be corrected (7). The inclination of the cutting plane - related to the foot axis - has an influence on the postoperative length of the first metatarsal (7, 46). This high variability provides a remarkably wide choice for the surgeon to perform a three dimensional correction; on the other hand, it makes the exploration of the biomechanical effects of the sliding components *separately* extremely difficult.

The more-than-one plane (usually two-plane) osteotomies provide a greater bony surface, which is beneficial for the healing of the osteotomy. Lateral and plantar shifting can easily achieved; however, the extent of lateral shifting determines the magnitude of plantarisation and vice versa. After all, the correction of the pronation of the distal metatarsal fragment can be achieved by a relatively complicated series of resections of the osteotomized surfaces.

The literature forms a common view in terms of the desired extent of lateral shifting of the distal fragment: the aim is the biggest correction available, as the overcorrection is definitely inhibited by the 2nd metatarsal. Nevertheless, the optimal extent of the plantarisation has not yet gained consent (11, 24, 70). Opinions are even more controversial according to the extent of shortening of the first metatarsal: some authors emphasize the beneficial effect of the shortening on the soft tissue balance, while others claim that the shortening can be the leading factor of the postoperative pain - the so called transfer metatarsalgia - beneath the second to fifth metatarsal heads (11, 23, 24, 44, 61).

However, I could not find any report on correlations between the prevalence and magnitude of the transfer metatarsalgia and the *separate* extent of the correctional components (shortening, plantarisation, lateral shifting) of the distal fragment.

3. HYPOTHESES

The hypotheses of the present study were:

When having a single-plain distal metatarsal osteotomy performed,

1. the more the shortening of the first metatarsal, the higher the prevalence and magnitude of a transfer metatarsalgia on the 2-5th metatarsal heads
2. the higher the correction on either the HVA or the first-second IMA, the less the prevalence and magnitude of a transfer metatarsalgia on the 2-5th metatarsal heads
3. the more the shortening of the first metatarsal, the less the patients' satisfaction with the cosmetic result of the surgery
4. pedographic analysis shows an increased (similar to normal) load amount at the first metatarsal head region at post op stage compared to the preoperative (less than normal) value
5. pedographic analysis points out an increased overall gait dynamics after the surgical procedure

4. PATIENTS AND METHODS

4.1. Patients

The patients of this study were provided by two departments.

4.1.1. Department of Orthopaedics, County Hospital of Miskolc

A *retrospective* follow-up evaluation was performed on 327 of the 545 hallux valgus cases that have been operated in the period of 1994 to 1998. As the procedures were divided into two groups according to the extent of shortening of the first metatarsal (see chapter 4.2.1. below), and the results of the evaluation on the two groups were published separately, the demographic data are also detailed separately as follows.

1: Of the 407 below described Lindgren-Turan (LT) (38) subcapital osteotomies (chapter 4.2.1.), a follow-up examination was available on 240 feet (59%) of 135 patients (129 women, 6 men) with an average age of 52.5 (SD 12.1) years. 105 of the procedures were bilateral (99 women, 6 men). The patients were reviewed an average of 4.2 (SD 1.3) years postoperatively.

2: of the 138 Wu (72) osteotomies, 87 cases (63%) were available for follow-up (51 patients: 41 women, 10 men). 36 of the patients had bilateral procedure (34 women, 2 men). The mean age of the patients at the follow-up was 52.3 (SD 14.4) years. The mean follow-up time was 4.2 (SD 1.4) years.

4.1.2. Department of Orthopaedics, Medical University of Szeged

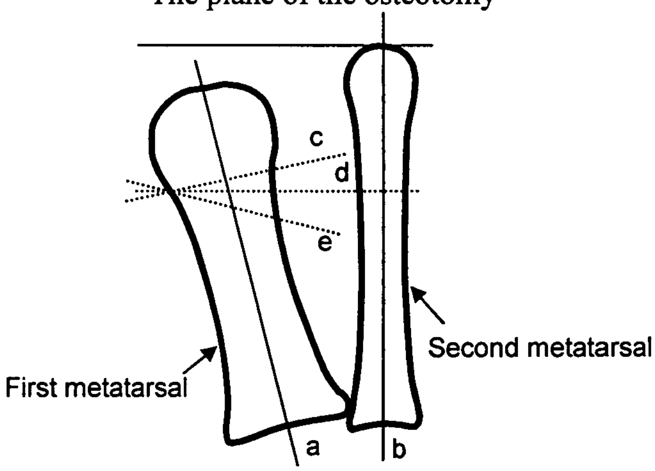
Of the 76 feet of 47 hallux valgus patients that have been operated in the period of 1991 to 1994 by the LT (38) procedure, 34 feet (45%) of 21 patients were available for a complex (radiological, physical and pedographic) *prospective* follow-up. The mean age of the patients at the time of surgery was 49.9 (SD 13.6) years; the mean follow-up time was 7.5 (SD 1.3) years.

4.2. Surgical method and indication criteria

4.2.1. Surgical method

A distal, subcapital, single-plane, double-oblique osteotomy - first described by Wilson (71), modified by Lindgren and Turan (38) and Wu (72) - was performed for the correction of the abnormal HVA and first-second IMA at all patients. The procedure is carried out as follows: a dorso-medial, slightly curved incision is used. The medial eminence of the first metatarsal head is removed by oscillating saw. The osteotomy is usually done slightly obliquely according to the longitudinal axis of the first metatarsal, which results in a mild to moderate shortening of the first metatarsal when the distal part is shifted laterally. A lateral displacement resulting in a shortening was defined as a LT operation, while a lateral shifting of the distal fragment causing a lengthening or a maintained first metatarsal length was defined as a Wu procedure (Fig. 8.).

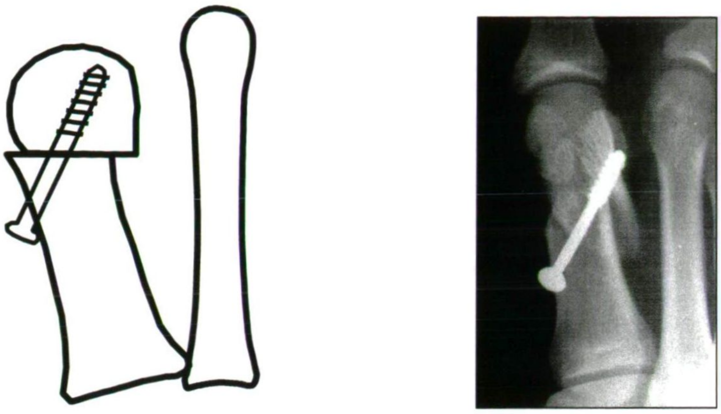
Figure 8.
The plane of the osteotomy



a: axis of the first metatarsal; b: axis of the second metatarsal; c: plane of osteotomy for lengthening; d: plane of osteotomy for length preservation (c + d: Wu procedure); e: plane of osteotomy for shortening (Lindgren-Turan procedure)

A plantarisation of two to three millimetres is performed. Any pronation of the great toe is corrected by rotation of the distal fragment. The fixation is ensured by a single small fragment AO (Synthes) cancellous screw (Fig. 9.).

Figure 9.
The fixation of the osteotomy



An immediate load bearing on the heel and on the lateral edge of the foot is allowed. Full weight bearing on the medial aspect of the foot is allowed six to eight weeks post op.

All the operations had been performed by the same group of 6 surgeons.

Complications: We did not observe any non-union among the 327 patients. Delayed union was detected in five cases (two of them suffering from rheumatoid arthritis); these were treated by prolonged non-load bearing. Superficial wound infections found in two cases were treated by surgical debridement and antibiotics.

4.2.2. Indication criteria

The selection criteria for the surgery were a 1-2 IMA 12 to 25 degrees, a HVA 25 to 45 degrees, and no evidence of stage 2 or higher osteoarthrosis according to Kellgren and Lawrence (31) at the first metatarso-phalangeal joint. Those hallux valgus patients who did not meet these criteria were treated by other surgical techniques. Neuromuscular disturbances, diabetes mellitus medicated with insulin and rheumatoid arthritis in Steinbrocker's stage (55) 3 or higher were exclusion criteria.

4.3. Examination methods

Three different methods for the data recording were used in the study.

4.3.1. Status recording sheets

- The preoperative and early postoperative physical status and complaints of the patients operated on at the Orthopaedic Department of Szeged in the period of 1991 to 1994 were recorded on a combined questionnaire-status sheet (Appendix 1.) developed by the fellows of the current study.

- A more detailed status recording sheet was constructed for the follow-up at the Orthopaedic Department of the Miskolc County Hospital in 1999 (Appendix 2.). A great attention was paid to the accurate X-ray analysis. A detailed documentation of the lesser ray metatarsalgia, the first MTP joint ROM, and the cosmetic outcome was performed, by a five-point scale for the magnitude of each:

location and magnitude of metatarsalgia: very severe pain – 1 point, severe pain – 2 points, moderate pain – 3 points, mild pain – 4 points, pain-free – 5 points.

satisfaction with the appearance of the foot: poor – 1 point, satisfactory – 2 points, good – 3 points, very good – 4 points, excellent – 5 points.

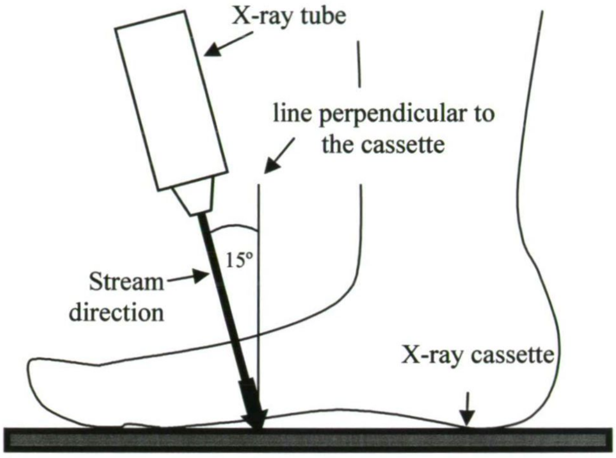
first MTP joint ROM: 0-15° – 1 point, 16-35° – 2 points, 36-55° – 3 points, 56-75° – 4 points, >75° – 5 points.

- For the long-term follow-up performed at the Orthopaedic Department of Szeged after 1999, an internationally widely accepted scaling system was applied. The score was published in 1994 (34), and it summarizes the consensus of the American Orthopaedic Foot and Ankle Surgeons (AOFAS) on foot scoring. In this hundred-point scale, a maximum of 40 points for pain, 45 for function, and 15 for foot alignment can be given. The original English version of the score can be seen in Appendix 3.

4.3.2. Radiological evaluation

Standardized dorso-plantar and lateral X-ray pictures are crucial for appropriate evaluation. At this study, the dorso-plantar views were taken with the ray tube tilted 15 degrees dorsally (perpendicularly to the metatarsals), positioned to 100 cm from the foot (Fig. 10.). As the forefoot bones are not more than two to three cm above the film cassette at postural position, the magnification of the final picture will not exceed three percent, which can be ignored.

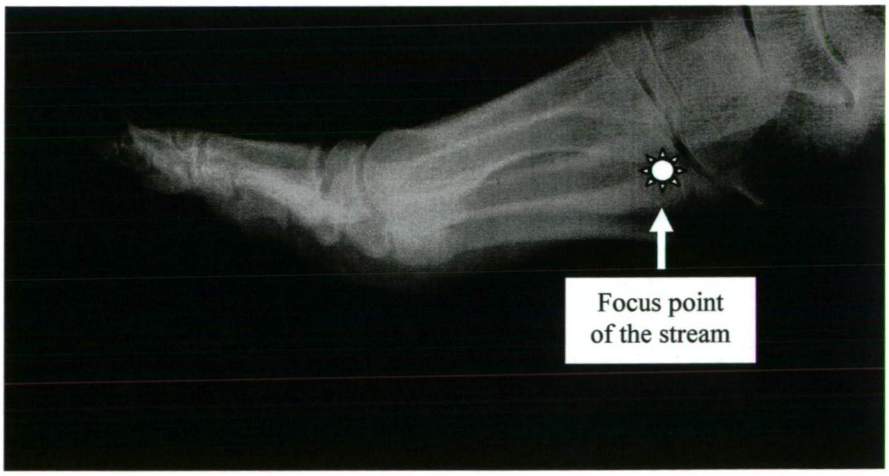
Figure 10.
The acquisition of the dorso-plantar X-ray picture



a: positioning of the X-ray tube *b: the dorso-plantar X-ray picture*

The lateral views were taken with the ray stream focused on the base of the third metatarsal, perpendicularly to the longitudinal axis of the foot (Fig. 11.).

Figure 11.
The lateral X-ray picture

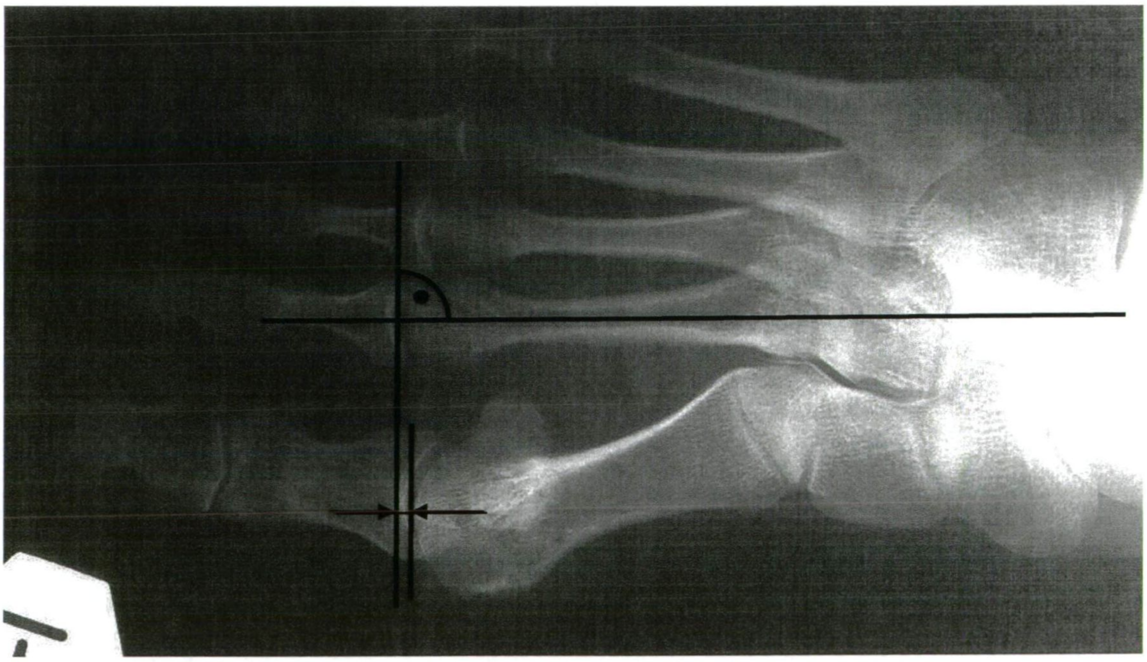


The following data were measured on the radiograms, by the principles described in section 2.4.2.:

- HVA
- first-second IMA
- shortening of the first metatarsal
- sesamoid position
- plantarisation of the distal fragment of the first metatarsal

The shortening of the first metatarsal was defined as the difference between the postoperative and the preoperative 1-2 index. The measurement of the 1-2 index can be seen in Figure 12.: a line is compiled perpendicularly to the axis of the second metatarsal at the most distal point of the head; if this line runs more distally than the most distal point of the first metatarsal head, the 1-2 index gains a negative value. If this line intersects the head of the first metatarsal, the 1-2 index is positive. This method provides more accuracy than the comparison of the pre- and postoperative length of the first metatarsal separately, as it remarkably extinguishes the magnification effect of the radiogram.

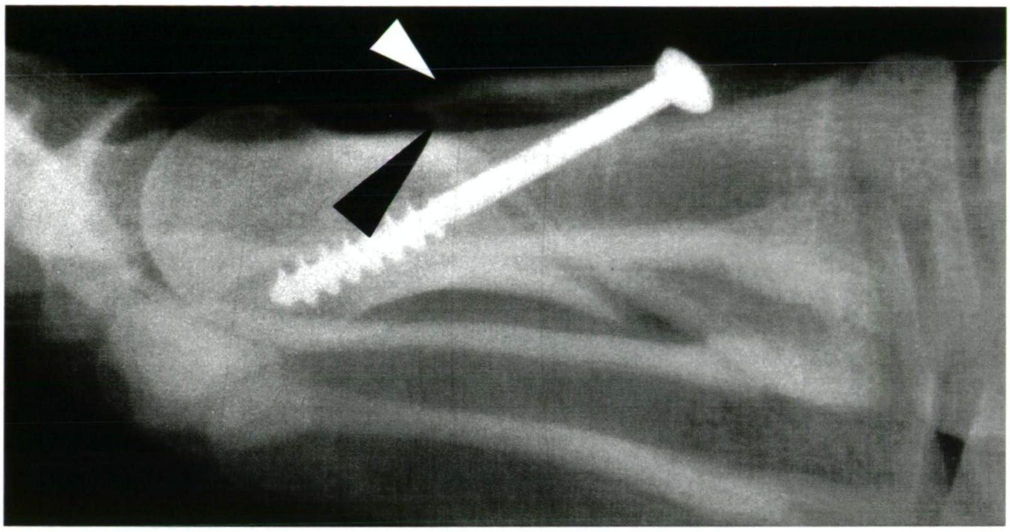
Figure 12.
Compilation of the 1-2 index



The distance between the apexes of the arrows is the 1-2 index, which is actually negative, as the first metatarsal is shorter than the second one

The magnitude of plantarisation can be measured on the side view (Fig. 13.).

Figure 13.
Measurement of the plantarisation on the side X-ray picture



The distance between the tip of the black and the white arrow demonstrates the extent of plantar shifting of the distal fragment

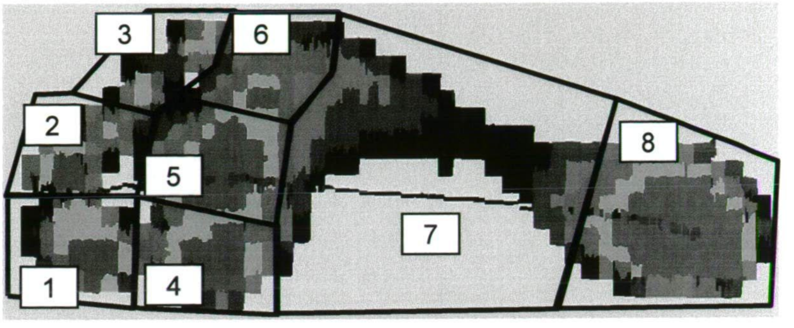
4.3.3. Pedography

All the patients that are involved into the current study were examined by a pedography analyser device. However, only the pedograms of the cases having been operated at the Szeged Orthopaedics Department were analysed in this study, as this group had a complete pre- and postoperative record for comparison (the other patients had only a *retrospective* follow-up examination).

The acquired summary picture of the footprint was divided into eight separate sections (Fig. 14.). The pre- and postoperative contact time values as well as pressure-time integral values of the total foot area and the foot portions were calculated and compared to each other by statistical analysis.

Pressure conditions are highly influenced by the patients' body weight (66). In this study, there was no significant deviation in the patients' body weight at the two compared groups (same patients, preoperative vs. postoperative conditions), so this factor could be abandoned from the statistical calculation.

Figure 14.
The division of the total foot area into sections.



1: hallux; 2: toes 2-3.; 3: toes 4-5.; 4: head of first metatarsal; 5: head of metatarsal 2-3.; 6: head of metatarsal 4-5.; 7: midfoot; 8: heel

4.4. Statistical analysis

For the statistical evaluation of the correlations, Spearman's nonparametric rank correlation test was used.

For comparison of the pre- and postoperative data at the prospective part of the study, student's pairwise t-test was applied.

5. RESULTS

5.1. Retrospective analysis of the Lindgren-Turan and Wu procedures performed in 1994 to 1998 in Miskolc

We measured a mean HVA of 40.3 (SD 4.4) degrees before surgery and 14.2 (SD 6.2) degrees after osteotomy at the Lindgren-Turan (LT) group, which represents a mean correction of 26.1 (SD 5.3) degrees (SD: standard deviation). At the Wu group, the mean pre- and postoperative HVA values were 41.5 (SD 3.0) and 12.9 (SD 4.7) degrees, respectively, with a mean correction of 28.6 (SD 5.0) degrees.

At the LT group, the mean 1-2 IMA was 18.5 (SD 3.1) degrees pre op, and 10.1 (SD 2.9) degrees post op; the correction was 8.4 (SD 4.3) degrees. At the Wu patients, the mean pre- and post op 1-2 IMA was 22.2 (SD 2.4) and 10.0 (SD 2.3) degrees, respectively; consequently, the mean correction of the IMA was 12.2 (SD 1.8) degrees.

The mean shortening of the first metatarsal was 3.8 (SD 1.8) mm at the LT patients, while a mean *lengthening* of 0.3 (SD 1.0) mm was measured at the Wu group.

The Kropej score indicated a decline of 3.4 (SD 0.7) and 3.0 (SD 0.6) in the sesamoid position at the LT and Wu patients, respectively.

The plantar shifting of the head of the first metatarsal was 2.7 (SD 0.7) mm and 2.5 (SD 0.6) mm at the LT and Wu group.

The levels of metatarsalgia for rays 2 to 5 at the LT patients are presented in Table 1. The same data of the Wu cases can be seen in Table 2.

Table 1.
The magnitude of metatarsalgia for rays 2 to 5 at the LT group *(n=240)*

Rays		2	3	4	5
Pain-free (5 points)		125	180	218	232
Metatarsalgia	mild pain (4 points)	71	39	11	4
	moderate pain (3 points)	37	19	10	3
	severe pain (2 points)	7	2	1	1
	very severe pain (1 point)	0	0	0	0

Table 2.
The magnitude of metatarsalgia for rays 2 to 5 at the Wu group *(n=87)*

Rays		2	3	4	5
Pain-free (5 points)		76	83	86	86
Metatarsalgia	**mild pain (4 points)**	11	4	1	1
	moderate pain (3 points)	0	0	0	0
	severe pain (2 points)	0	0	0	0
	very severe pain (1 point)	0	0	0	0

The patients' postoperative aesthetic satisfaction score was 4.5 (SD 0.7) and 4.7 (SD 0.5) at the LT and Wu patients, respectively.

A first MTP joint ROM score of 4.6 (SD 0.9) for the LT group, and 4.9 (SD 0.4) for the Wu group was calculated.

Correlations between the parameters at the LT group:

- A positive correlation was found between metatarsalgia in ray 2 and the shortening of the first ray ($r=-0.271$, $p<0.01$). A similar result was observed for metatarsalgia in rays 3 ($r=-0.255$, $p<0.05$) and 4 ($r=-0.517$, $p<0.05$), but not in ray 5 ("r" means the correlation coefficient, "p" means the level of significance).
- There was no correlation between metatarsalgia in rays 2 to 5 and the decrease in the HVA ($p>0.11$) or the 1-2 IMA ($p>0.32$).
- A highly positive correlation was observed between the patients' satisfaction with their postoperative foot alignment and the decrease in the HVA ($r=0.328$, $p<0.001$).
- There was a negative correlation between the patients' satisfaction with their postoperative foot alignment and the extent of first ray shortening ($r=0.201$, $p<0.01$).
- No correlation was detected between the patients' satisfaction with their postoperative foot alignment and the 1-2 IMA, the sesamoid position and the plantarisation of the distal fragment.

Correlations between the parameters at the Wu group:

- A longer first metatarsal resulted in a significantly lower incidence and level of metatarsalgia in rays 2 (r= -0.395, p<0.001) and 3 (r=-0.241, p<0.01), but not in rays 4 (r= -0.071, p=0.5) and 5 (r=-0.145, p=0.09),
- There was no correlation between the level of 2-5 metatarsalgia and the decrease in either the HVA (r varies from 0.053 to 0.157, p≥0.1) or the 1-2 IMA (r scores between 0.026 and 0.199, p≥0.06).
- The postoperative decrease in the HVA correlated positively with the degree of satisfaction of the patients with their foot alignment (r=0.427, p<0.001).
- There was no correlation between the patients' satisfaction with their postoperative foot alignment and either the extent of the first metatarsal lengthening or the 1-2 IMA, the sesamoid position and the plantarisation of the distal fragment.
- Data showed no correlation between the level of 2-5 metatarsalgia and either the extent of plantarisation on the distal fragment, or the change in the sesamoid position.
- There was a very close correlation between the extent of decrease in the HVA compared to the one in the IMA.

5.2. Prospective analysis of the Lindgren-Turan procedures performed in 1991 to 1994 in Szeged

A mean preoperative HVA of 36.8 (SD 5.5) degrees, while a postoperative HVA of 19.6 (SD 10.4) degrees was measured. The deviation is significant (p<0.001)

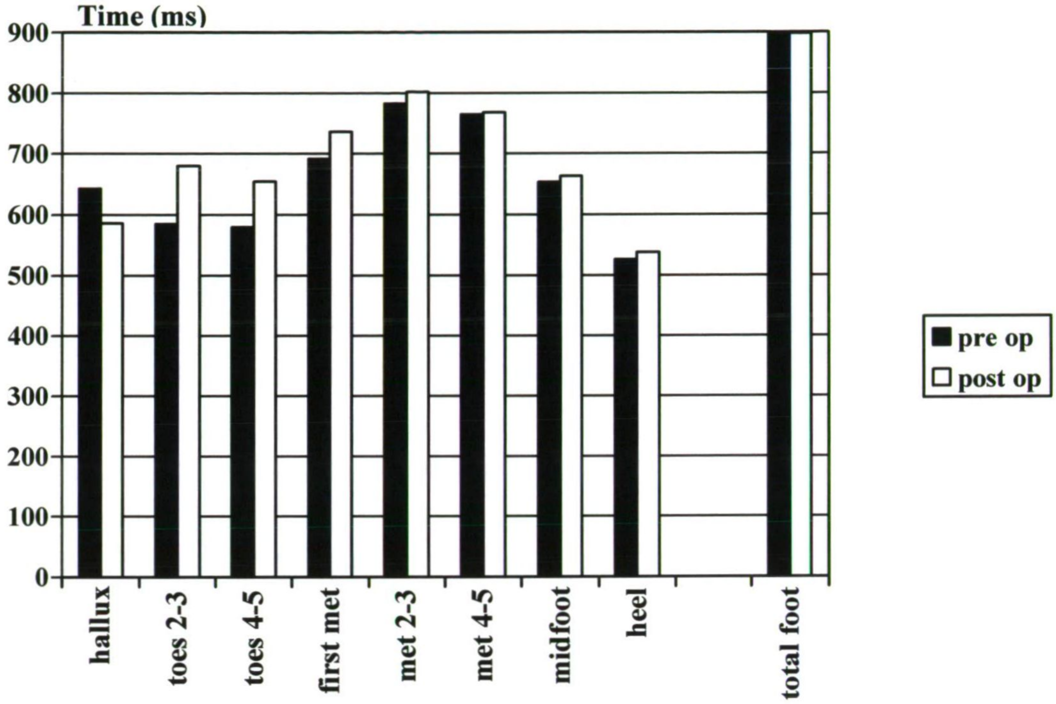
The 1-2 IMA was 13.3 (SD 3.4) degrees pre op, and 8.5 (SD 2.1) degrees post op. The difference is significant (p<0.01).

The mean AOFAS score of the 34 cases at the follow-up was 82.0 (SD 14.9).

Pedographic analysis

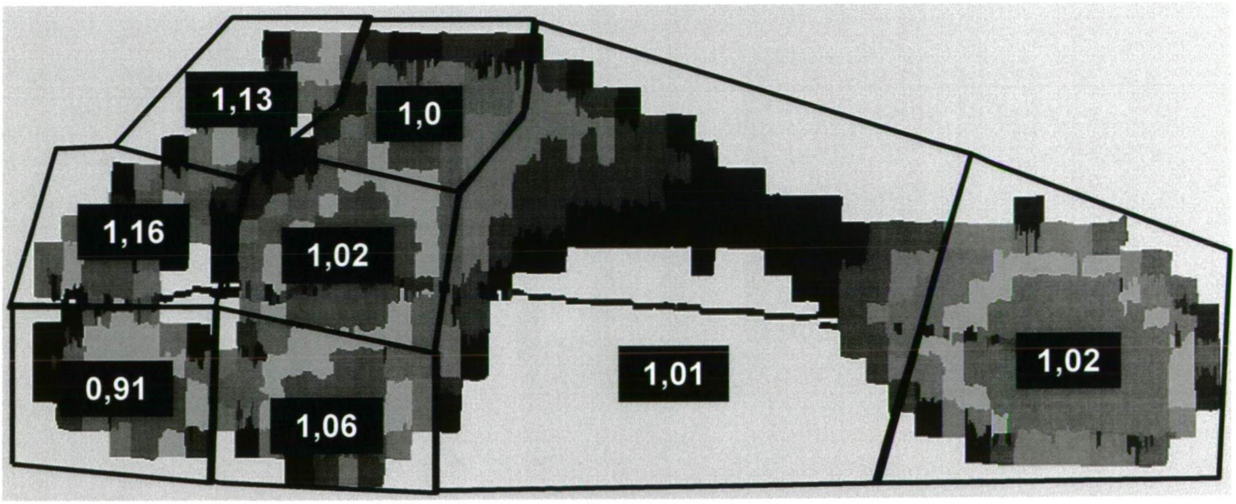
The contact time values of the total foot and the single areas are presented in Figure 15. The contact time of the total gait was 900 (SD 202) ms pre op, and 898 (SD 115) ms post op. The contact time of the hallux showed a postoperative decline of nine percent, while that of all the other areas increased by 0.4 to 16 percent (Fig. 16.). The above deviations are not statistically significant.

Figure 15.
Contact time values of the single foot areas and the total foot



met.: head of the metatarsal

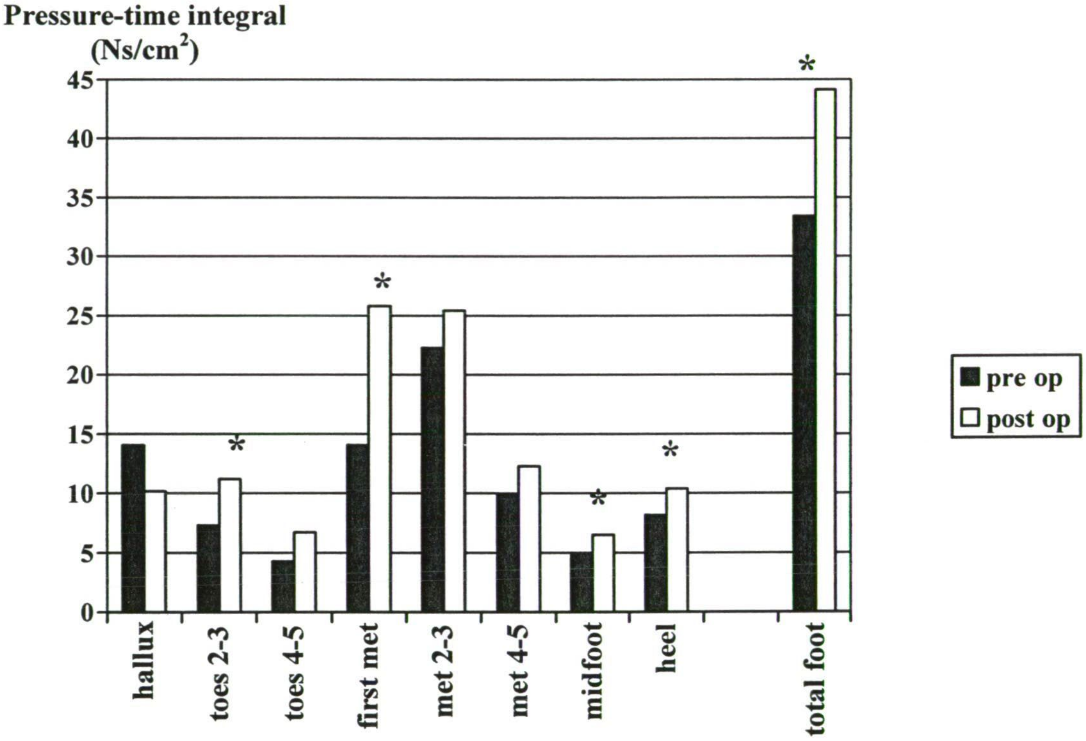
Figure 16.
The alteration of the contact time values



Values show the quotient of the post- and preoperative contact time values, which represent the alteration of the contact time

The pre- and postoperative pressure-time integral („load amount") values can be seen in Figure 17. Except for the hallux, an increase was detected at every single area and at the total foot as well (total foot: the preoperative 33.4 /SD 11.6/ Ns/cm^2 value increased to 44.1 /SD 14.9/ Ns/cm^2 post op). Any significant alterations are marked with * in the figure.

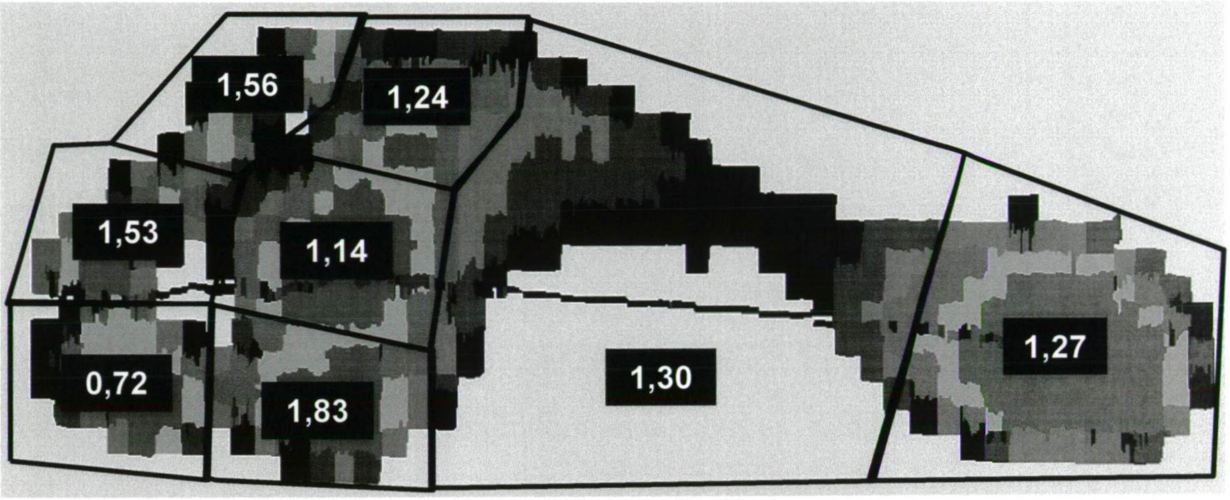
Figure 17.
Pressure-time integral values of the single foot areas and the total foot



met.: head of the metatarsal

Figure 18 contains the quotient of the post- and preoperative pressure-time integral values. For the total foot, the ratio is 1.32 (44.1/33.4). A massive increase was measured in the region of the first metatarsal head (83 percent); besides, the highest increase was found at the lesser toes (53 and 56 percent, see Fig. 18.). The postoperative pressure-time integral of the hallux decreased to 72 percent of its preoperative level.

Figure 18.
The alteration of the pressure-time integral values



Data represent the quotient of the post- and preoperative pressure-time integral values

6. DISCUSSION

Surgical correction of the hallux valgus is one of the most common orthopaedic operations worldwide. Understanding the pathological biomechanics of the HV and analysing the changes of the foot conditions following its correctional surgery may help us to choose the most appropriate surgical technique from surgeon's and patient's point of view as well.

Elder age and female gender seems to increase the occurrence of HV (20, 21, 71). Non-fitting footwear and poor function of the joints of the foot is considered as an etiological factor as well (48).

A surgical procedure for HV is indicated, when there is pain around the first MTP joint, when foot function is affected, or when the usage of a regular shoewear shows difficulties. The huge number of published surgical methods for HV surgery (39) indicates that no single operation itself is appropriate for each hallux valgus case. The indication for a particular procedure is influenced by the forefoot conditions (HVA, IMA, prominence of the medial aspect of the first metatarsal, subluxation of the sesamoids, evidence or lack of osteoarthrosis in the first MTP joint etc.) and surgeon's preference. As a principle, a mild to moderate HV deformity (HVA less than 35 degrees) can be effectively corrected by a distal (subcapital) first metatarsal osteotomy (3, 14, 38, 71, 72).

If the osteotomy is performed in a single plane, the distal fragment can be shifted laterally and plantarly, and also can be rotated in a wide range. Lateral sliding decreases the first-second IMA, and secondarily, the HVA as well. Plantarisation restores the dropped transversal arch (56). The rotation corrects the pronation of the great toe (7). The inclination of the cutting plane of the osteotomy influences the postoperative length of the first metatarsal (7, 46). This high variability of a three dimensional correction makes the exploration of the biomechanical effects of the sliding components *separately* extremely difficult.

The common consent for the extent of lateral shifting of the distal fragment is the biggest correction available. However, the optimal extent of the plantarisation has not yet clarified (11, 24, 70). Opinions are even more controversial according to the extent of shortening of the first metatarsal: some authors emphasize the beneficial effect of the shortening on the soft tissue balance (1, 13, 35), while others claim that the excessive shortening can be the leading factor of the development of postoperative transfer metatarsalgia beneath the 2nd to 5th metatarsal heads (11, 23, 24, 44, 61). Some studies (8, 73) advise the Weil procedure (shortening of the lesser ray metatarsals) for the compensation of the shortening of the first metatarsal; others recommend keeping the original length of the first metatarsal during osteotomy in order to avoid the onset of lesser ray metatarsalgia (2, 74).

Discussion of the retrospective part of the study

We evaluated the clinical and radiological data of 327 feet of 186 patients having been operated by either the Lindgren-Turan (38) or the Wu (72) distal first metatarsal osteotomy 4.2 years post op. The main task of the follow-up was to find any correlation between the transfer metatarsalgia and the *separate* extent of the correctional components (shortening, plantarisation, lateral shifting) of the distal fragment. Besides, the effect of the sesamoid position on the postoperative transfer metatarsalgia was also evaluated. Any connection between the patients' satisfaction rate with the cosmetics of the procedure and the above parameters was checked as well.

Comparing the postoperative values with the preoperative ones at the 327 cases (LT + Wu group), the mean correction of the HVA and the 1-2 IMA was about 27 and 10 degrees, respectively. The plantarisation of the head of the first metatarsal was approx. 2.6 mm. A decline of 3.2 points at the Kropej score was measured.

The mean shortening of the first metatarsal was 3.8 mm at the LT patients, while that of the Wu group was -0.3 mm; the latter value means a *lengthening* of the metatarsal.

We found that a longer first metatarsal results in a lower occurrence and degree of transfer metatarsalgia at rays 2 and 3 at either the LT or the Wu group; at the LT group, metatarsalgia of ray 4 showed the same correlation with the first metatarsal length. However, we could not prove any significant correlation between the ray 5 metatarsalgia and the first metatarsal length at each group. These findings suggest that the avoidance of shortening of the first metatarsal during osteotomy may decrease the onset of a late postoperative transfer metatarsalgia on the middle rays. We haven't found any publication that analyses the relationship between the shortening of the first metatarsal, the location of metatarsalgia and the severity of pain in the different locations in detail.

Plantarisation as well as reposition of the head of the first metatarsal onto the sesamoids seems to play an important role in the restoration of the weight-bearing capacity of the hallux (11, 24, 70), which corresponds with our clinical experience, so we usually perform a plantarisation of up to 3 mm. Our aim was to reveal any correlation between the *alteration* (not the postoperative value) of the level of plantarisation or the level of sesamoid reposition and the degree of lesser ray metatarsalgia. In the present study, we could not verify any statistical correlation between these values, however. This result may derive from the relatively low mean and standard deviance value of the plantarisation, and the low statistical range value of the sesamoid reposition.

The decrease in the HVA showed a close correlation with the decrease in the 1-2 IMA at the Wu patients. This means that a greater level of correction of the HVA during the osteotomy results in a smaller 1-2 IMA, which is highly recommended at any first metatarsal osteotomies for hallux valgus surgery.

We could not prove any connection between the onset and magnitude of metatarsalgia in rays 2 to 5 and the decrease in either the HVA or the 1-2 IMA. This result may be considered surprising, but it emphasizes that the correction of the HVA and IMA itself may not reduce the overload of the dropped transversal foot arch.

The LT patients were significantly more pleased with the appearance of their foot when the shortening of the first metatarsal was less intensive. This indicates that patients prefer operations with the minimum possible shortening for aesthetic reasons. However, we did not find any correlation between the length of the first metatarsal and the patients' cosmetic satisfaction rate at the Wu group; this might be due to the very low alteration (and low SD value) of the first metatarsal length.

A greater degree of correction of the hallux malalignment proved to lead to a higher level of patients' satisfaction with the foot appearance at each group.

Discussion of the prospective part of the study

The aim of this part of the study was to determine the long term clinical, radiological and pedographic results of the 34 Lindgren-Turan osteotomies which were available for the long term follow-up (mean 7.5 years, minimum of five years).

The mean postoperative HVA and 1-2 IMA was 19.6 and 8.5 degrees, respectively. The relatively poor HVA value may be the consequence of the high preoperative HVA (36.8 degrees) and the long follow-up period. The postoperative 1-2 IMA maintained a value which is under the widely accepted limit (nine degrees) of a normal IMA.

The mean AOFAS score (see complete AOFAS scale in Appendix 3.) of the 34 cases at the follow-up was 82 points.

Pedographic analysis

Comparing the postoperative contact time values of the total foot and the individual areas to the preoperative ones, no significant alteration was found. However, the post op values of all foot areas but the hallux showed a tendency of increasing (0.4 to 16 percent). At the hallux, a decrease of nine percent was measured. These data, although not being significant, suggest that the gait dynamics is restored at the postoperative stage (a more dynamic step results in a relatively longer contact time of the single foot regions). The decrease in the post op contact time of the hallux might be the consequence of the shortening of the first metatarsal (approx. 4 mm), which results in a relative longer tendon apparatus of the great toe. This latter effect can decrease the functional availability of the hallux at the toe-off phase of the gait (18, 32).

The pressure-time integral values showed an increase postoperatively at all foot areas but the hallux. The proportion of this raise is not the same: 14 to 56 percent was found at the total foot, the heel, the midfoot and the metatarsal heads and toes of rays 2 to 5, which is typical for an improving gait dynamics. The much higher (83 percent) rate of increase at the pressure-time integral data of the head of the first metatarsal is remarkable, however. The explanation of this change may be a painful first metatarsal head before surgery, the loading of which is kept off to avoid pain. The high increase of the pressure-time integral virtually shows a load bearing capacity that closes up to the normal one. The reduced role of the hallux is again well demonstrated by its depressed postoperative pressure-time integral value, which corresponds well with the observation described at the contact time section above.

As a consequence, a good late postoperative clinical and radiological outcome was found at our patients operated on with the Lindgren-Turan subcapital first metatarsal osteotomy for hallux valgus. The pedographic data emphasize the fact that a shortening of approx. 4 mm can lead to a depressed great toe function. On the base of these findings we have already revised our operating technique: an even less shortening of the first metatarsal is routinely performed during subcapital osteotomies.

7. CONCLUSION

As a summary of the discussion, the hypotheses of the study can be answered as follows:

Following a single-plain distal first metatarsal osteotomy:

1. A shorter first metatarsal results in a higher occurrence and magnitude of transfer metatarsalgia on rays 2 and 3. On the lateral rays the tendency is similar, although the correlations are not significant.
2. The magnitude of correction of either the hallux valgus angle or the 1-2 intermetatarsal angle does not influence the onset and magnitude of transfer metatarsalgia.
3. A shorter first metatarsal results in a lower patients' satisfaction rate with the foot alignment and cosmetics.
4. The first metatarsal head region shows a heavily increased load amount at the postoperative stage, which tends to the normal values.
5. Pedography suggests an increased overall quality of gait dynamics at all the foot regions. The exception is the great toe: it shows a marked loss of function during ambulation.

The above detailed conclusions of the study are of remarkable importance to the author's opinion. They point out the fact, that during a corrective osteotomy for hallux valgus, a greater care should be taken of the conservation of the first metatarsal length and the plantarisation besides the correction of the first metatarsus varus and the hallux valgus deformity in favour of maintaining the hallux function and avoiding the development of postoperative metatarsalgia.

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A. APPENDIX

Appendix 1.

Pre- and postoperative questionnaire for hallux valgus patients (1991 to 1994)

Name:...
Date of birth:...
Date of surgery:.......................................
Patient's body weight:...........kg
Foot examined (right/left):.............
Type of surgery (Brandes/Regnauld/Wilson):.................

I. Subjective complaint pre op
1. Duration of complaints (months)..........
2. Hallux alignment pre op ....
A. X-ray hallux valgus angle ....
B. X-ray intermetatarsal angle ....
3. Ortosis pre op
A. orthopaedic shoe
B. insole
4. Complaints that led patient to doctor:
A. pain of the bunion
B. mallet toe deformity
C. mallet toe+superposition
D. pain of the bunion+claw toe
E. pain at roll over
F. cosmetic condition
G. pressure pain beneath the second toe

II. Subjetive complaint post op
1. Duration of complaints (months) ....
2. Hallux alignment post op ....
A. X-ray hallux valgus angle ....
B. X-ray intermetatarsal angle ....
3. Ortosis post op
A. orthopaedic shoe
B. insole

III. What kind of complaints are evident at the follow-up?
A. no complaints
B. widened forefoot (pes transversoplanus)
C: mallet toe (digitus malleus)
D. transitoric pain at load
E. pressure pain beneath the first toe
F. pressure pain beneath the second toe
G. pressure pain beneath the third toe
H. pressure pain beneath the fourth toe
I. pressure pain beneath the fifth toe
J. irritative bursa
K. hallux rigidus
L. sensitivity to weather conditions
M. loss of sensitivity at the area of incision
N. pain in the MTP joint

O. inflammation
P. keloid
Q. recurrence of bunion

IV. How is the patient satisfied with the functional outcome of the surgery?
A. very satisfied
B. satisfied
C. unsatisfied

V. How is the patient satisfied with the cosmetic outcome of the surgery?
A. verysatisfied
B. satisfied
C. unsatisfied

VI. Would the patient undergo the surgery again?
A. yes
B. no

VII. Objective state
1. active range of motion of theMTP1
A. flexion ....
B. extension ....
2. passive range of motion of theMTP1
A. flexion ....
B. extension ....

VIII. Complications post op
A. infection
B. sliding of the great toe
C. bone necrosis
D. bone resorption

IX. X-ray pre op
1. MTP-ben levő elváltozás
A. arthrosis
B. subluxatio
C. luxatio
2. Brandes: joint space ....mm
3. Regnauld: joint space ....mm
4. Wilson: joint space ....mm

X. X-ray post op
1. MTP-ben levő elváltozás
A. arthrosis
B. subluxatio
C. luxatio
2. Brandes: joint space ....mm
3. Regnauld: joint space ....mm
4. Wilson: joint space ....mm

XI: Decrease of the intermetatarsal angle on X-ray .... angle

XII. Other surgeries added to the original intervention:
A. tendon lengthening
B. removal of osteophytes
C. Hohmann-procedure

XIII. Known comorbidity
A. rheumatoid arthritis
B. gout
C. osteoporosis
D. previous trauma

XIV. EMED: pressure beneath the great toe at toe-off N/cm2

Date of follow-up: .... Done by: ....

Appendix 2.

Pre- and postop status sheet of hallux valgus patients in the period of 1994 to 1998

Patient's name:

Date of birth:

Date of surgery:

Side of surgery (R/L):

Magnitude of postop metatarsalgia (1-5): I:.... II:.... III:.... IV:.... V:....

Sole clavus: I II III IV V

Hallux valgus angle (physical): ....

MTP joint ROM (1-5): ....

Preop. need for insole (Y/N):......

Postop. need for insole (Y/N):......

Postop. need for orthopaedic shoe (Y/N):......

Esthetic satisfaction (1-5): ....

Hallux valgus angle	preop:	postop: ....
1-2. intermetatarsal angle	prop:	postop: ....
1-2. index	preop:	postop: ....

Sesamoid displacement (1-5): ....

Appendix 3.

AOFAS Hallux Metatarsophalangeal-Interphalangeal Scale

Date of follow-up:
Patient's name:
Date of birth:
Body weight:
Side: LEFT RIGHT

Pain (40 points):	
None	40
Mild, occasional	30
Moderate, daily	20
Severe, almost always present	0
Function (45 points)	
Activity limitations:	
No limitations	10
No limitation of daily activities, such as employment responsibilities, limitation of recreational activities	7
Limited daily and recreational activities	4
Severe limitation of daily and recreational activities	0
Footwear requirements	
Fashionable, conventional shoes, no insert required	10
Comfort footwear, shoe insert	5
Modified shoes or brace	0
MTP joint motion (dorsiflexion plus plantarflexion)	
Normal or mild restriction (75° or more)	10
Moderate restriction (30-74°)	5
Severe restriction (less than 30°)	0
IP joint motion (plantarflexion)	
No restriction	5
Severe restriction (less than 10°)	0
MTP-IP stability (all directions)	
Stable	5
Definitely unstable or able to dislocate	0
Callus related to hallux MTP-IP	
No callus or asymptomatic callus	5
Callus, symptomatic	0
Alignment (15 points)	
Good, hallux well aligned	15
Fair, some degree of hallux malalignment observed, no symptoms	8
Poor, obvious symptomatic malalignment	0