Subtalar arthroereisis in the treatment of flat-foot deformity: the pros and the cons

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Abstract

Artrodeza subtalară în tratamentul deformității piciorului plat: pro și contra

Lucrarea prezintă analiza literaturii referitor la starea actuală a problemei utilizării artrodezei subtaliare în tratamentul deformității piciorului plat la copii și adulți. Sunt expuse informații despre indicații și contraindicații în acest tip de tratament și potențialele complicații.
Autorii conchid că în literatura de specialitate poate fi observată existența unor opinii contradictorii în această problemă, fiind subliniate atât eficiența acceptabilă și avantajele evidente ale acestui procedeu, cât și riscurile unor complicații care impun necesitatea intervențiilor repetate sau dezvoltarea unor stări ireversibile ale piciorului. Prezintă interes utilizarea acestei metode la copii și adulții cu afecțiuni neuromusculare, având ca obiectiv limitarea indicațiilor pentru utilizarea metodelor chirurgicale non-fiziologice.

Cuvinte cheie: artrodeză subtalară, deformitate de picior plat, tratament chirurgical

Abstract

The article presents the analysis of the literature on the current state of the problem of the use of subtalral arthroeresis in the treatment of flat foot deformity in children and adults. Information on indications and contraindications in this type of treatment and potential complications are exposed. The authors conclude that contradictory opinions can be observed in the specialized literature, emphasizing both the acceptable efficacy and the obvious advantages of this procedure, as well as the risks of complications that require the necessity of repeated interventions or the development of irreversible states of the foot.It is of interest to use this method in children and adults with neuromuscular disorders, aiming at limiting the indications for the use of non-physiological surgical methods.

Keywords: subtalral arthroeresis, flat foot deformity, surgical treatment

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Introduction

Over the last decades there has been an increase in the number of children and adolescents with feet abnormalities. According to different authors, the plano-valgus deformity cases number equals to 35-50% of all the cases of children feet abnormalities [25, 67, 68]. It shall be noted that the plano-valgus deformity develops slowly and can be asymptomatic and painless for a long time, but in future pain and lameness may appear, as well as sensitivity disorders and trophic disturbances; feet joints mobility may be limited; arthritic phenomena may develop in the feet joints with the corresponding progression of dysfunction [25, 27, 38, 63]. There are few approaches in treatment of plano-valgus deformity:

- conservative way (used in 90-95% of cases)
- surgical treatment is advised in cases of persistent pain, progression of deformity and/or dysfunction of limbs, existence of trophic disturbances and failure of conservative treatment [25, 40, 48, 55].

One of the modern variants of surgical treatment of plano-valgus deformity of children and adults is the so-called subtalar arthroereisis solely or in combination with other types of treatment [24, 53, 59]. According to the encyclopedic dictionary of medical terms, the term "arthroereisis" (lat. athroereisis – arthron – joint + ereisis – lifting) means lifting of the joint[78]. Consequently, subtalarar throereisis is the type of surgical treatment aimed at limiting the excessive foot eversion and pronation of calcaneus while maintaining supination range of motion in the subtalar. Arthroereisis is performed by installing a special implant (of different designs, forms and materials) in the sinus tarsi.

Furthermore, all the authors emphasize that the implants for subtalararthroereisis are installed within the sinus tarsi and canalis tarsi where there is no chondral layer, i.e., this area is not articular, so the treatment is extra-articular. Sinus tarsi is an anatomical formation limited with ankle and calcaneus bones, ankle-calcaneus-navicular joint in front and rear facets of subtalar at the rear. A sinus tarsus is represented by 3 separate articular facets separated by canalis tarsi: the front and the middle facets lie distally, and the rear facet lies proximally from the canalis tarsi [73].

The term "subtalar arthroereisis" was introduced in the early XX century by Putti V., and in native medicine the term "lateral artroris" was introduced by Turner G.I. in 1930. Under this term the operation for limiting the mobility of subtalar by artificial bone barrier was meant. The method itself was originally developed for treatment of children flatfoot; however, later the indications were extended to adults. Del-Torto (Italy, 1927) was one of the first surgeons who performed arthroereisis using this type of treatment for correction of deformities in children aged 5-17 with complete or partial paraplegia (Tamoyev S.K., 2012) [49]. In 1946, Chambers E.F. announced the implementation of extra-articular subtalararthroereisis using a bone graft [8]. He tried to limit the foot eversion by removing a small portion of the anterior process of the calcaneus with bone grafting of the defect. This reduced range of motion in the subtalar and contributed to setting the foot in a functional position.

Grice D.S. (1952) used autograft from tibia bones of the patient to correct valgus at paralytic platipodia. He set the autograft in the sinus tarsi and called it an "extra-articular" subtalararthrodes, referring to integrity of articular surfaces of the subtalar. According to the literature, this operation is performed rarely due to the high risk of degenerative process in the subtalar [15].

Later various authors proposed different variants of implants for subtalararthroereisis: Vilandot [12] – used to use fibular part for arthroereisis later Subotnick S.I. (1974) described installation of inert silicone implants (elastomer) into the sinus tarsi; Smith S. (1975) first used the UHMW-polyethylene "STA-peg" implants; Valenti G. and Langford J. et al developed a helicoid structure with cylindrical shaped cutting (1987); Maxwell J. et al (1997) developed a titanium screw implant; many other scientists worked at this topic as well[13, 32, 35, 44, 59].

Study purpose: to present the current state of problem of use of subtalar arthroereisis in treatment of planovalgus deformity in children and adults, information about indications and contraindications to this type of treatment and possible complications based on analysis of the literature.

Material and Methods

During the study the data from the literature over the past 10 years were analyzed, References were made to previous works on application of subtalararthroereisis in children and adults with planovalgus deformity.

Results

The analysis of literature data shows that at present special attention is given to the biomechanical role of location of ankle bone relative to tibia and orientation of the axis of subtalar in the context of planovalgus deformity. Particularly, the concept of rotational equilibrium of foot relative to the axis of subtalar is being considered. Normally subtalar is placed obliquely, deflected from the horizontal by 42° in the sagittal plane and by 16° from the median longitudinal foot axis in the lumbar plane. Thus, the subtalar is a simple joint with the axis of rotation behaving like an "... oblique door hinge" [20, 34, 41, 69].

The purpose of subtalar arthroereisis is restoration of normal anatomic proportions in the joints of the hindfoot and optimization of static-dynamic loads pattern. Roth S. et al. claimed that at installation of an implant in subtalar the correction is achieved by stimulation of proprioception, which provides for permanent

nature of correction [41]. It is also believed that by limiting external pronation moments and increasing supination moments in subtalar not only the planovalgus deformity can be eliminated, but also the biomechanics of walking can be changed by changing the spatial location of the heel-ankle axis [46].

Considering the large number of options and different functional roles of implants for subtalararthroereisis, Vogler H.M. (1987) [51] suggested their classification:

a) implants functioning as a self-locking wedge;
b) implants altering the position and arrangement of the heel-ankle axis;
c) implants functioning due to direct compression action on the lateral process of ankle bone.

Indications for subtalar arthroereisis and additional procedures at planovalgus deformity

Most authors agree that subtalar arthroereisis alone can be considered as an option of treatment of "flexible" planovalgus deformity of I-II degree in children and adults. The results show that treatment of patients with planovalgus deformity by the method of subtalar arthroereisis is less traumatic and highly effective and promotes rapid and adequate restoration of supporting ability. However, the question of advisability of performing subtalar arthroereisis still remains. Some authors indicate that subtalar arthroereisis can be performed in patients aged 6-8, the other consider starting age to be 10-12 [10, 28, 52].

Many of the works point to the need to consider at the treatment of planovalgus deformity both the degree of deformation and its possible combination with other foot pathologies (dysfunction of posterior tibial muscle, additional navicular bone, forefoot pathology, etc.) [14, 48, 70, 74]. Based on the concomitant feet pathology combined treatment is used, including surgery on soft tissues (including achilloplastic operation, channeling of chorda of posterior tibial muscle) and bones (medialized calcaneus osteotomy, arthrodesis of talus-navicular joint, correction arthrodesis of calcaneus-cuboid joint, the so-called "+/-" osteotomy of cuboid and the 3 sphenoid bone and reconstruction of forefoot – by indications, etc.) [16, 30, 56, 77, 79].

Analysis of literature shows that in pathogenesis of planovalgus deformity, especially in adults, considerable attention is paid to dysfunction of posterior tibial muscle. In this regard a special tactic of examination was developed (clinical tests to determine the posterior tibial muscle dysfunction), classification (four-grade by Johnson K.A. and Storm D.E.) and methods of surgical treatment of this pathology [21, 39, 57, 59].

At the initial stages of widespread use of implants for subtalar arthroereisis the surgical treatment process was developed for use primarily for children, as the researchers hoped that with the child's growth the arthroereisis will help to prevent the development of secondary signs of excessive movement in hindfoot; that is, the earlier the subtalar complex becomes stable, the sooner the excessive load on the muscular system will be eliminated [2, 5, 23]. Currently most researchers agree that subtalararthroereisis in children and adults is advisable in case of persistent pain, feet dysfunction and failure of conservative treatment, but this intervention does not exclude other more traumatic and complex operations, if necessary [1, 4, 54].

Separately the discussion shall be considered which is held by supporters and opponents of subtalar arthroereisis in cases of paralytic or spastic planovalgus deformity. According to several review articles and recent thesis works it becomes clear that this problem is far from its final solution. First and foremost, this is due to the mechanistic approach to treatment of children with planovalgus deformity on the background of neurological disease and underestimation of neurophysiological mechanisms underlying the formation of feet deformities. There is also a question about the advisability of early surgery treatments with the aim of eliminating pathological settings and contractures in the lower limbs joints in connection with their possibly low efficiency and high recurrence rate [22, 33, 43, 65].

For example, Kenis V.M. in his works compared the effectiveness of planovalgus deformity treatment in children with infantile cerebral paralysis, by performing osteoplastic subtalar arthroereisis (34 patients, 56 feet) on the one hand and with subtalararthroereisis implants (46 children, 74 feet) on the other. The author comes to the conclusion that "...clinical indications for the osteoplastic arthroereisis is the pronational variant of foot deformity: children aged 5-7 with hindfootvalguse for more than 30° - as the main method; in children aged 8 - 11 with hindfootvalguse for more than 20° - as the main method. Indications for implant arthroereisis is the presence of pronation variant of deformity in children aged 5-7 with hindfootvalguse for up to 20° as the variant method"[23, 61, 66]. The author successfully used implants of various designs, including those of biodegradable material, in the treatment of mobile planovalgus deformities in children with infantile cerebral paralysis [62].

At the same time Ryzhikov V.D., 2011, in his candidate's dissertation proposed and validated diagnostic and treatment algorithm of choice of an optimal method of treatment of equinoplanovalgus deformity in children with infantile cerebral paralysis based on the patient's age, level of motor skills, severity of foot deformity, but does not even mention the subtalar arthroereisis [42].

Umnov D.V. (2010) showed that for elimination of planovalgus deformity in patients with infantile cerebral paralysis the corrective osteotomy of the calcaneus is the optimal method of surgical treatment, as is not

accompanied with a loss of function of the subtalar, in contrast to extra-articular subtalar arthrodesis operation, considering the comparable clinical and radiographic outcomes of both surgeries. The identified comparability of reconstructive capacities and efficiency of these two variants of treatment leaves, according to the author, the ability to use technically easier (in comparison with osteotomy) surgical operation in the form of extra-articular subtalar arthrodesis in a limited group of patients with overweight and questionable prospect of movement without assistance [50].

Bolotov A.V., 2015 proved that the use of minimally invasive methods of surgical treatment with use of submerged implants during the execution of subtalar arthroereisis in patients with myelodysplasticplanovalgus deformity promotes early activization of patients and improves the quality of life of patients [7]. Despite many developed methods of surgical treatment of flatfoot in children with the effects of neurological diseases, it can be stated that still need to be clarified age and clinical indications for the use of extra-articular stabilizing procedures and corrective osteotomies of the bones of the foot in children with this pathology [18, 58, 60, 64, 71, 76].

Complications and contraindications to subtalar arthroereisis

The analysis of literature data shows that the most common complications when performing subtalar arthroereisis are the following: syndrome of the ankle sinus; persistent pain in sinus tarsi; spasm of the peroneal muscles; the wrong choice of an implant leads to hypo- or overcorrection of the deformity; fracture of the subtalar implant; reaction to a foreign body; migration of the implant; limitation of motion of the foot joints [6, 17, 30, 37, 47, 75]. Rarer, but yet possible complications can be the following: superficial or deep infection; avascular necrosis, cystic changes or fracture of talus/calcaneus; synovitis, bursitis, capsulitis; need for additional operations; increasing pain in the knee and/or hip joint and lumbus [26, 45]. However, the literature data speak of a small number of certain complications and usually their description is limited to reports of several cases. In addition to it, some complications, such as complaints on pain in the operated foot during walking, do not require repeated interventions and can be corrected by the patient himself during 2-3 months after walking pattern change and normalization of load on foot or removed by local treatment and introduction of anti-inflammatory drugs in the subtalar area.

Many orthopedic surgeons stress the fact that if between the moment of setting the implant in the subtalar and the moment of possible occurrence of need of its deletion is more than 1-1.5 years, then the foot stays in the normal position, i.e., planovalgus deformity relapse does not occur [17, 43, 75].

One of the major drawbacks of this type of treatment is the existence of certain limitations in physical activity in case of presence of a subtalar implant in the title, for example jumping and contact sports activities are undesirable [32].

During the period since 1990 to 2004 De Pellegrin M. performed subtalararthroereisis in 152 children (82 boys and 70 girls) in 74 cases with bilateral pathology, in a total of 226 feet; the mean age was 10.6 +/- 1.9 years. The author obtained good results in 95.4% of cases, with complications in 4.6% of cases [11].

Contraindications to subtalar arthroereisis performing can be divided into surgical and orthopedic ones. The first group includes: age less than 8, high risk of development of suppurative processes in place of surgery and presence of specific infections in the body (tuberculosis, etc.), mental illnesses and severe somatic condition. The second group includes significant post-traumatic and congenital planovalgus deformity, rigid foot deformity with significant arthritic changes in joints and overweight [11, 26, 45, 75].

Analysis of the results of subtalar arthroereisis in treatment of planovalgus deformity

It shall be emphasized that the works on biomechanical modelling of subtalar arthroereisis with the use of implants of different design and studies of change of position of the talus and subtalar in cadavers show the change in contact stresses in subtalar and ankle joint after subtalararthroereisis. Martinelli N. et al. (2012) [31] studied fresh frozen cadaveric specimens for distribution of contractual pressure in feet joints of the foot in normal condition, at planovalgus deformity and after setting the Kalix implant in the sinus tarsi and it is shown that subtalararthroereisis restores the normal intra-articular pressure in subtalar. In a cadaver study J.C. Christensen and his colleagues found that changing the position of talus affects the location of other foot bones, which subsequently was confirmed in special X-ray studies [3, 9, 36].

Husain Z.S. and Fallat L.Y. revealed quantitative changes in the degree of restriction of movements in subtalar depending on the implant size. They found that the range of motion in subtalar was reduced by 32.0 – 44.8 – 58.0 – 65.5 and 76.8% when using implants with a diameter of 6, 8, 9, 10 and 12 mm, respectively [19]. Most of the analyzed works containing explanation of late results of subtalar arthroereisis in treatment of planovalgus deformity from a perspective of the evidentiary medicine are at the 3 and (what is more often) at the 4 level of evidence, i.e. the medium- and long-term retrospective studies of a certain group of operated patients are held, sometimes the results of subtalararthroereisis are compared in two age groups of patients, more rarely there is a comparison of results of subtalar arthroereisis with other types of operations

(such as medialized calcaneus osteotomy or Evans osteotomy) [6, 11, 47].

Loskutov O.A. in 2015 presented the results of treatment of 126 patients (204 feet) aged from 5 to 39 with planovalgus deformity and dysfunction of posterior tibial muscles using subtalar arthroereisis in the period from 2 to 5 years. Revision surgery was performed in 5 patients, removal of the implant – in 1 patient. The author came to the conclusion that subtalararthroereisis is less traumatic and highly effective and promotes rapid and adequate restoration of supporting ability [28]. According to Tamoev S.K., 117 patients aged from 18 to 32 (193 feet) in a period of 4 years after subtalar arthroereisis the following results were obtained: excellent – after 144 operations (74.61%); good – after 39 operations (20.20%); satisfactory – after 7 operations (3.62%); unsatisfactory – after 3 operations (1.55%) [49]. According to our research, De Pellegrin M. et al. had the greatest experience: since 1990 to 2012 he collected data on 485 patients who underwent subtalararthroereisis (247 –two sides arthroereisis, 238 – monolateral arthroereisis). The average age of patients was 11.5 ± 1.81 (range 5.0-17.9). Based on more than 20 years of experience, the authors believe that subtalar arthroereisis is the best method for correction of planovalgus deformity. However, they emphasize the necessity of setting precise indications for this type of treatment [11].

Conclusions. As can be seen from the above, the analysis of literature data on treatment of planovalgus deformity using subtalar arthroereisis showed the existence of contradictory views on this issue. On the one hand, most authors emphasize sufficiently high effectiveness of this operation (60-95.4% of excellent and good results) together with other obvious advantages – less traumatic and minimally invasive treatment, relatively low cost, early verticalization and timely rehabilitation, which meets modern requirements in orthopedics. Also one of the advantages of this procedure is that later it is possible to perform more complicated and traumatic operations if it is required according to the clinical situation.

On the other hand, this method can pose some complications not excluding repeated procedures and development of irreversible states in the hindfoot.

The question of combination of arthroereisis with other operations on different parts of foot and different soft tissue and bone structures depending on the patient's age and degree of foot deformity remains open. Another promising direction of research is the development of indications and contraindications to arthroereisis in children and adults with neuromuscular diseases. Further implementation of minimally invasive preventive procedures (including arthroereisis) will provide an opportunity to prevent formation of severe multiplanar feet deformities in children with infantile cerebral paralysis and other neuromuscular diseases and will also allow to limit the indications for complex non-physiological surgery.

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