UNIVERSITÉ TOULOUSE III – PAUL SABATIER
FACULTÉS DE MÉDECINE

ANNÉE 2019 2019 TOU3 1660

THÈSE

POUR LE DIPLÔME D'ÉTAT DE DOCTEUR EN MÉDECINE

MÉDECINE SPÉCIALISÉE CLINIQUE

Présentée et soutenue publiquement

par

Marianne SALIB
le 13 Novembre 2019

Quels sont les critères cliniques et instrumentaux guidant le choix d'une chirurgie correctrice d'un pied équin-varus chez les adultes cérébrolésés ? Une revue systématique de la littérature.

Directeur de thèse : Dr David GASQ

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Au président du jury

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Cependant, pour savoir quel tendon couper à Hippolyte, il fallait connaître d'abord quelle espèce de pied-bot il avait.

Il avait un pied faisant avec la jambe une ligne presque droite, ce qui ne l'empêchait pas d'être tourné en dedans, de sorte que c'était un équin mêlé d'un peu de varus, ou bien un léger varus fortement accusé d'équin. Mais, avec cet équin, large en effet comme un pied de cheval, à peau rugueuse, à tendons secs, à gros orteils, et où les ongles noirs figuraient les clous d'un fer, le stréphopode, depuis le matin jusqu'à la nuit, galopait comme un cerf. On le voyait continuellement sur la place, sautiller tout autour des charrettes, en jetant en avant son support inégal. Il semblait même plus vigoureux de cette jambe-là que de l'autre. À force d'avoir servi, elle avait contracté comme des qualités morales de patience et d'énergie, et quand on lui donnait quelque gros ouvrage, il s'écorait dessus, préférablement.

Or, puisque c'était un équin, il fallait couper le tendon d'Achille, quitte à s'en prendre plus tard au muscle tibial antérieur pour se débarrasser du varus ; car le médecin n'osait d'un seul coup risquer deux opérations, et même il tremblait déjà, dans la peur d'attaquer quelque région importante qu'il ne connaissait pas.

Madame Bovary, Extrait chapitre XI, Deuxième partie de Gustave Flaubert (1857)

SALIB Marianne 20XX TOU3 15XX

Quels sont les critères cliniques et instrumentaux guidant le choix d'une chirurgie correctrice d'un pied équin-varus chez les adultes cérébrolésés ? Une revue systématique de la littérature.

RESUME EN FRANÇAIS :

Objectif.

Rapporter les données préopératoires orientant le choix des techniques chirurgicales dans la prise en charge du pied équin-varus (PEV) chez le patient cérébrolésé.

Méthode.

La méthodologie PRISMA a été respectée. Toutes les études notifiant une chirurgie du PEV du cérébrolésé en langue anglaise ou française et sans limitation de dates ont été incluses. La stratégie de recherche a concerné quatre bases de données (PUBMED, MEDLINE, COCHRANE, PEDRO). La qualité des études a été évaluée avec le score MINORS.

Résultats.

60 études (n= 2291 patients) ont été analysées, et concernaient des neurotomies (n=523), des allongements isolés de la loge postérieure de jambe (n=437), des transferts antérieurs du tibial antérieur (n=888), du long fléchisseur des orteils ou de l'hallux (n=249), du long extenseur de l'hallux (n=102), du tibial postérieur (n=41) et du long fibulaire (n=41). Une étude concernait spécifiquement la réalisation d'arthrodèses (n=10).

Les neurotomies étaient réalisées en cas d'équin spastique, non rétractés dans 87% des cas.

La motricité des releveurs de pied n'était évaluée que dans 70% et 27% des études concernant les neurotomies et les allongements isolés, respectivement, et notifiaient un testing supérieur à 2 en MRC pour 50 à 75% des études ainsi qu'une contraction sélective ou syncinétique pour 77% des patients.

Lors des transferts tendineux antérieurs, la motricité était relevée dans 20% à 46% des études, et la présence d'une activation musculaire à la marche dans 46 à 56% des études. Même si la présence d'une contraction volontaire favorisait un meilleur résultat, c'était la correction d'un varus qui justifiait le transfert du tibial antérieur dans 60% des études contre 30 % pour les autres transferts, ces derniers étant justifiés par leur hyperactivité musculaire ou leur possibilité de contraction volontaire.

Conclusions.

Cette revue souligne l'hétérogénéité des approches chirurgicales dans la prise en charge du PEV, et a permis de proposer une évaluation standardisée permettant d'adapter le choix des techniques à chaque patient

TITRE EN ANGLAIS : **Which clinical and instrumental criteria to guide the choice of surgical correction of equino-varus foot in brain-damaged adults? A systematic scoping review.**

DISCIPLINE ADMINISTRATIVE : Médecine spécialisée clinique

MOTS-CLÉS : Foot Deformities, Acquired; Hemiplegia; Orthopedic Procedures; Tenotomy; Tendon Transfer; Neurosurgical Procedures

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Table des matières

Contexte du travail

L'incidence des AVC en France est estimée à 140 000/an. Parmi les survivants, 40% garderont des séquelles [1]. Cela représente la 3ème cause de mortalité [2] et la 1ère cause de handicap acquis chez l'adulte. Une déformation fréquemment rapportée au niveau des membres inférieurs est le pied équin-varus, son incidence étant estimée à 18% dans une étude prospective à 1 an post-AVC chez des patients pris en charge dans un service de rééducation, avec près d'un tiers des déformations fixées [3].

Dans une démarche d'amélioration fonctionnelle, de nombreux patients sont adressés pour une évaluation et une proposition de prise en charge dans les services des Explorations Fonctionnelles Physiologiques et de Médecine Physique et de Réadaptation du CHU de Toulouse. La consultation médicochirurgicale de spasticité est un lieu privilégié de discussion entre les thérapeutes et le patient. Afin d'élargir et de systématiser les discussions et les décisions de prise en charge médicochirurgicales, des réunions de concertations pluridisciplinaires entre médecins MPR, orthopédistes et neurochirurgiens ont été instaurées : les situations cliniques y sont discutées sur la base d'un bilan clinique et de vidéos, souvent complétées par les données d'une analyse quantifiée de marche et/ou d'un bloc moteur anesthésique. Dans tous les cas, les suggestions thérapeutiques sont toujours confrontées aux attentes du patient, la prise en charge proposée étant le fruit d'une décision partagée entre le patient, et son entourage selon les situations, et les thérapeutes.

Cette discussion systématisée nous a permis de soulever de nombreuses questions qui concernent notamment les bases physiopathologiques des déformations en équin-varus, dont la compréhension est un prérequis à la proposition d'une technique chirurgicale de correction. Les données apportées par l'analyse quantifiée de la marche et la réalisation des blocs moteurs anesthésiques apportent des éléments supplémentaires à la réflexion, renforçant notre sentiment qu'il n'existe pas à l'heure actuelle de consensus sur l'indication des techniques chirurgicales du pied équin-varus chez le patient cérébrolésé adulte. Voici une liste des questions en suspens : Quelles sont les données de l'évaluation pré-chirurgicale guidant le choix des techniques chirurgicales visant à affaiblir certains groupes musculaires et à compenser les fonctions déficientes par un transfert tendineux ?

L’objectif attendu d’un transfert tendineux est-il simplement la restitution d’un appui plantigrade et/ou la restauration d’une flexion dorsale de cheville obtenue par un effet ténodèse passif ou par une contraction musculaire volontaire ?
La combinaison d’une « réanimation » de la flexion dorsale de cheville à un allongement ou une neurotomie de la loge postérieure de jambe doit-elle être systématique ?

Ces interrogations sont actuellement traitées par l’expérience professionnelle et institutionnelle, et les réponses apportées par chacune des équipes médico-chirurgicales peuvent différer.

L’objectif de notre travail est d’apporter des éléments factuels à ces interrogations dans le cadre de la chirurgie du pied équin-varus chez le patient cérébrolésé adulte. Nous avons mené une revue systématique de la littérature qui a permis de recueillir les éléments cliniques et paracliniques préopératoires déterminants les indications chirurgicales dont les points clés sont l’évaluation des rétractions dans les décisions d’allongements, l’évaluation de l’hypertonie spastique dans celle des neurotomies et l’évaluation de la motricité dans la réalisation ou non des transferts tendineux pour réanimer la flexion dorsale de cheville.

Liste des abréviations

ADF-KE/KF ankle dorsiflexion knee extended/knee flexed
APF ankle plantar flexion
AROM active range of motion
ASH Ashworth
BRS Brunnstrom scale
BTI botulinum toxin injection
Cl Clonus
CR case report
CS case serie
CT calcaneal tendon
EBM Evidence Base Medicine
EHL extensor hallucis longus
FDL/FDB flexor digitorum longus/brevis
FHL/FHB flexor hallucis longus/brevis
GM (M or L) gastrocnemius (medial or lateral)
MAS Modified Ashworth scale
MINORS Index for Non-Randomized Studies: score on 24 for type I & II, score on 16 for type III
MRC Medical Research Council Scale
N number of feet operated in the study
NB nerve block
PFR plantar fascia release
P/R prospective/retrospective study
PROM passive range of motion
SPLATT split anterior tibialis tendon transfer
SwP swing phase
StP: stance phase
TA tibialis anterior
TP tibialis posterior
TAR Tardieu scale
TN tibial nerve
TP tibialis posterior
RCT randomized controlled study
SD standard deviation
X-apo/-l/-t/-r muscle aponevrotomy/lengthening/transfer/release
I randomized controlled study
II comparative study (retrospective or prospective)
III case series (retrospective or prospective)

Which clinical and instrumental criteria to guide the choice of surgical correction of equino-varus foot in brain-damaged adults? A systematic scoping review.

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Abstract

Objective. To report preoperative outcomes guiding the choice of surgical techniques to correct equino-varus foot (EVF) in brain-injured adults.

Methods. The PRISMA methodology was followed. Included studies notifying EVF surgery on brain-injured adults were included regardless of their level of proof, in English or French language, without date limitations. A search strategy was applied to four databases (PUBMED, MEDLINE, COCHRANE, PEDRO). The quality of studies was assessed with the MINORS score.

Results. 60 studies (n=2291 patients) were analyzed and concerned neurotomies (n=523), calf musculotendinous lengthening (n=437), anterior transfer of tibialis anterior (n=888) or alternative anterior transfers with the flexor digitorum/hallucis longus (n=249), the extensor hallucis longus (n=102), the tibialis posterior (n=41) and the peroneus longus (n=41). One study was dedicated to arthrodeses (n=10).

Neurotomies were performed on spastic equinus that were not retracted in 87% of cases.

When no anterior transfer was performed, motricity of ankle dorsiflexors was assessed in 70% of neurotomy studies compared to 27% in isolated calf lengthenings, and in both cases they reported a muscular testing superior than 2 in MRC for 50 to 75% of studies and selective or syncinetic contraction for 77% of patients.

When anterior tendon transfers were performed, motricity of ankle dorsiflexors was reported in 20% to 46% of studies, and dynamic muscle activation during gait in 46% to 56% of studies. Even if a voluntary contraction favored a better functional result, it was the presence/correction of a varus that justified the tibialis anterior transfer in 60% of studies against 30% in other transfers, these latter being justified by their hyperactivity or voluntary contraction.

Conclusions. This review highlights the heterogeneity of surgical approaches in the management of EVF and has made it possible to propose a standardized evaluation allowing the choice of techniques well suited to each patient.

Keywords: Foot Deformities, Acquired; Hemiplegia; Orthopedic Procedures; Tenotomy; Tendon Transfer; Neurosurgical Procedures.

Introduction

We count almost 130 000 stroke in France every year [4] with an average age of onset of 73 years old [1] representing the 3rd cause of death with 10 to 30% of the patients who die in the following month [2]. 75% of the survivors are left with neurological damage which represents the 1st cause of acquired handicap in adults [1]. Even if about 80 % of the patients recover walking abilities, they have an altered walking pattern with decreased speed and high energy cost, compromising their autonomy and quality of life [5].

The most frequently reported lower limb deformation was the equinovarus foot (EVF) which corresponds to an excessive ankle plantar flexion possibly associated with an hindfoot varus or an overall supination of the foot. Its incidence was estimated at 18% [7-33%] in a prospective study at 1 year post-stroke with about a third of them with fixed deformity [3]. EVF occurrence was attributed to an imbalance between hypertonic calf muscles of the leg and mostly paretic muscles of the anterior and lateral compartments [3,6], with sometimes the participation of intrinsic foot muscles [7]. The retraction was the complication of the muscular hypertonia, paresis and underutilization of the limb leading to change of the viscoelastic properties of the musculo-tendinous structures [8]. EVF limits participation in daily life activities [3], is a source of pain, can make the fitting laborious and restrict the transfer, standing and gait abilities [9].

Early rehabilitation, orthotic and pharmacological treatments of spastic foot are essential to lessen the hypertonia consequences and neuro-orthopedic complications [10–12]. When they are insufficient or when the patient wishes a more definitive solution, a surgical procedure is indicated. In current practice, functional outcomes (e.g. withdrawing orthoses or ankle instability) supports surgery procedures. An expert consensus using an analytic hierarchy process [13] highlighted that the benefit-risk balance and the functional response were part of the criterion choice of therapeutics. Two systematical literature reviews reported the effects and complication of EVF surgical corrections by orthopedic [14] and neurotomy [6] procedures in brain injured patients. Their outcomes were gait analysis, dynamic electromyography (EMG), the functional response by studying spatio-temporal parameters, technical aids uses and satisfaction [6,14] and also clinical response (voluntary motricity, PROM, muscular tonus) [6]. However, they challenged to find pre-operative selection criterion in their review, and they both recommend a quantified gait analysis as an objective and quantitative parameter to plan an adapted surgery [15]. The implication of surgical timing, musculotendinous contracture and the risk of late recurrence are also highlighted in neurotomy procedures [6].

To overcome this gap in literature and to support the choice of surgical procedures used in the management of EVF, this systematic scoping review aims to describe the pre-surgical clinical and instrumental criteria assessed and used to guide the surgical procedure of EVF in adult brain-injured patients.

Methods

PRISMA methodology [16] and its specific adaptation for scoping review [17] were used to guarantee the systematic character of the literature review. This review was not previously registered as a protocol.

Eligibility criteria

Participants adults (more than 18 years) presenting an acquired and non-degenerative brain injury (stroke, traumatic brain injury) complicated of an EVF surgically treated were considered. A comparative group (i.e. EVF non-surgically treated) was not required. Primary outcomes measures considered were at least the description of one clinical or instrumental pre-surgical criteria among the following criteria: ankle range of motion, ankle muscles motricity, ankle muscles activity or overactivity, ankle kinematic during the gait, gait abilities, use of an orthosis, completion of a preliminary selective anesthetic motor block or botulinum toxin injections. All publications meeting these eligibility criteria were selected, regardless of their level of evidence, the number of patients included, or the heterogeneity of the populations studied. Secondary outcomes measures consisted of comparison of pre- and post-surgical assessments (all previously mentioned criteria and subjective criteria) and description of adverse effects related to surgery. Authors opinion or synthesis publications were not integrated into the analysis, but their bibliographic references were screened to include additional studies. No publication date was imposed. Language publication was restricted to English and French.

Information sources and search strategy

We searched PubMed, Medline, Cochrane and PEDro databases for published studies until November 13th, 2017. An updating of the search on databases was made on August 15th, 2019. Search strategy used in PubMed is presented in **supplemental data Fig. S1**. Bibliographic references of selected articles were also inspected to include additional studies in this review.

Study selection and data extraction

Two reviewers (MS and FF) blindly selected the publications that fulfill eligibility criteria. Disagreements were resolved by a third reviewer (DG). **Figure 1** shows the study selection process as a flow diagram. Data were extracted by one of the authors, and then checked by a second author, from a specific data extraction sheet. Disagreements were resolved by discussions between the review authors.

Information was extracted from each included article on: (1) number and characteristics of participants (age, pathology causing the brain damage, severity of motor impairment); (2) characteristics of the surgeries (delay between surgery and brain damage, type and number of surgeries); (3) passive ankle range of motion (dorsiflexion and plantarflexion); (4) muscle strength of ankle dorsiflexor and plantarflexor muscles assessed with the Medical Research Council scale [18] and motor selectivity assessed with Brunnstrom scale [19,20] or others; (5) spasticity corresponding to a velocity-dependent increase of tonus caused by passive stretching of the muscle [21] assessed with Ashworth (original or modified) scale [22,23], Tardieu scale [24] or Brunnstrom [19] scale; (6) spastic cocontraction of calf muscles, corresponding to inappropriate recruitment triggered by the volitional command on ankle dorsiflexors [8], assessed by dynamic EMG or visual inspection during gait; (7) kinematic characteristics of the gait assessed by optoelectronic systems or visual inspection; (8) gait abilities and technical aids used (ankle-foot orthoses, orthopedic shoes, cane); (9) selective anesthetic nerve block of tibial nerve motor branches or botulinum toxin injections in calf muscles; (10) length of follow-up (i.e. delay of post-surgical evaluation); (11) evaluation of surgery success by comparing the evolution of the previously mentioned criteria and/or subjective criteria; (12) description of adverse effects related to surgery. Some studies described the effect of different surgeries without identifying the population characteristics for each type of surgery.

Risk of bias in individual studies

Because of the poor methodological quality of most of the studies included in the review, we used the Index for Non-Randomized Studies (MINORS), well suited to surgical case series, to further assess their quality [25]. Studies were sorted in descending order of proof level: prospective randomized controlled studies, non-randomized but controlled studies (prospective then retrospective), and case series (prospective then retrospective).

Synthesis of results

A qualitative synthesis of the results was proposed by differentiating 5 types of main surgery procedure: (1) calf muscles neurotomy; (2) tendon lengthening without anterior tendon transfer, concerning the calcaneal and/or tibialis posterior (TP) and/or flexor digitorum longus/brevis (FDL/FDB) and/or flexor hallucis longus (FHL) tendons, and/or the gastrocnemius aponeurosis; (3) anterior transfer of tibialis anterior (TA) tendon (split anterior tibialis tendon or complete tendon transfer); (4) anterior transfer of another tendon (TP, FDL, FHL, extensor hallucis longus [EHL]); (5) arthrodesis and/or osteotomy. Each of the 5 main types of surgery can be combined with other surgical techniques (i.e. associated surgeries), such as for example the calcaneal tendon lengthening in case of anterior transfer of TA tendon. Outcomes for each main type of surgery are presented in separated synthetic tables in the manuscript, and in full data tables in supplemental results.

Results

Neurotomy of calf muscles

Twenty-four studies (523 patients) reported neurotomy of calf muscles. Type of study, population characteristics and details of neurotomy surgeries were detailed in **Table 1** and described in **supplemental results**. **Table 2** summarizes clinical and instrumental criteria. **Supplemental Table S1** details all the criteria concerning neurotomy surgeries which were described in **supplemental results**.

Lengthening of calf muscles without anterior tendon transfer

Fifteen studies have reported 437 calcaneal tendons lengthening and/or gastrocnemius aponeurotomy without an associated anterior tendon transfer, corresponding to 15% to 100% of studies population. Type of study, population characteristics and details of isolated lengthening surgeries were detailed in **Table 3,** and described in **supplemental results**.
Table 4 summarizes clinical and instrumental criteria. **Supplemental Table S2** details all the criteria concerning isolated lengthening surgeries which were described in **supplemental results**.

Tibialis anterior transfer

Twenty-five studies reported split TA transfer (n=812) or complete TA transfer (n=76). Type of study, population characteristics and details of TA transfer surgeries were detailed in **Table 5 and** described in **supplemental results.**

Table 6 summarizes clinical and instrumental criteria. **Supplemental Table S3** details all the criteria concerning TA transfer surgeries which were described in **supplemental results**.

Anterior tendon transfer, with the exception of tibialis anterior

Thirteen studies (433 patients) reported anterior transfer involving muscles other than TA. Type of study, population characteristics and details of these surgeries were detailed in **Table 5** (second part) and described in **supplemental results**.

Table 6 (second part) summarizes clinical and instrumental criteria. **Supplemental Table S4** details all the criteria concerning these transfer surgeries which were described in **supplemental results**.

Osteoarticular surgeries

Osteoarticular procedures are very poorly represented in EVF surgeries and were not the main topic of studies carried out, except a case serie of talonavicular arthrodesis in chronic stroke patient with an EVF responsible for instability in stance phase [26]. The arthrodeses were described in 6 studies [27–32] as an associated surgery for 1 to 2 patients, and generally concerned talo-calcaneal, talo-navicular and calcaneo-cuboid joints. Arthrodeses were performed a few years after failure of a neurotomy or a tendon transfer [29,31,32] or initially in addition to a tendon surgery or neurotomy [27,28,30]. The objective was to obtain a plantigrade position and to stabilize the hindfoot [32]. A flat foot in stance phase could indicates arthrodeses [28].

Discussion

The aim of this scoping review was to highlight the clinical and paraclinical criteria used to guide the surgical management of EVF in adults with acquired brain lesions. However, this review doesn't allow to formally establish a consensual management guideline for several reasons. First, the methodology of studies, that are mostly retrospectives and non-comparatives, does not allow to identify inclusion criteria. The quality criteria of studies based on MINORS reveal frequent omissions. Secondly, we highlighted the absence of a standardized examination chart of the EVF which could guide the surgical choice. The assessment of hypertonia was rare in orthopedic approaches, and almost never assessed with standardized scales. Finally, it is striking to note a dichotomy between neurosurgical and orthopedic approaches with a physiopathological vision almost exclusively centered around

spasticity on non-retracted EVF for the first one, and a biomechanical logic more often at the retraction stage for the second one. Neurosurgical and orthopedic techniques are exceptionally combined, only in the case of neurotomies as the main surgery. One of the possible explanations lies in the fact that studies proposing an orthopedic approach were generally older than those offering neurotomies, and that the implementation of orthopedic and neurosurgical surgical techniques corresponds to distinct specialties, few surgeons mastering all the techniques used in neuro-orthopedics. Nevertheless, this review allows to extrapolate some information from the characteristics of the populations but also from the results and discussions of the authors, to propose a standardized minimal examination prior to EVF surgery, and finally to propose management guidelines.

Surgeries focused on the calf muscles: neurotomy and/or lengthening?

In neurotomies' studies, for which the data was the most detailed, spastic hypertonia was always assessed, often by use of chemical tests to differentiate it from a retraction that would require a specific treatment. Spasticity reduction alone allowed to control deformities in neurotomies' studies and yet they are rarely combined with orthopedic procedure: 8 studies report an equinus (<0°) [31–38] and only 3 combined neurotomy with lengthening [38–40]. Good results could come from a better expression of TA activation after spasticity management [34,36,41–43]. Recurrences on retraction could justify a complemental anterior transfer or a lengthening in future studies.

Lengthening alone were infrequent and practiced either in two populations: polypathological patients that cannot tolerate prolonged anesthesia or post-operative cares following a tendon transfer [44–46] and patients with a good motricity status of ankle dorsiflexors [44,47,48]. In the two studies reported equinus recurrence [47,49], spasticity could not be the only cause as we can also incriminate the type of lengthening since it was after a GM aponeurotomy (proximal or distal location not specified). Besides, ankle dorsiflexors strength was reported in only one of the two studies (BRS>3).

As neurotomy can only treat muscle hypertonia and not retraction, an assessment of the deformation reducibility with motor nerve block or botulinum toxin injections seems consensual to increase the success of the surgery, since the results of motor nerve block on spasticity reflects the results after neurotomy [37,40,50,51]. Besides, searching spastic cocontraction during the gait would be more relevant than only evaluate spasticity because it could explain recurrence of EVF.

Conversely, tendon lengthening is indicated in presence of retraction. The recurrence of equinus can be due to hypertonia not supported during an orthopedic procedure or to presurgical retraction not supported during neurotomy procedure. Thus, the two techniques are complementary especially in the early stages of spastic myopathy when the mechanisms are combined [8]. If during neurotomies gestures some tendon lengthening procedure have been proposed, the opposite is exceptional, and the two techniques are rarely associated in clinical practice.

The questions of associating neurotomies with tendon lengthening, in addition to the choice of surgical procedure used to length calf muscles (aponeurotomy or tendon lengthening), raise the question of the consequences of postsurgical loss of propulsive force. The choice of the lengthening technique is important because in theory strength is more preserved after gastrocnemius aponeurotomy than a calcaneal lengthening [52]. This fear justified FDL/FHL transfer on calcaneum [53], however, it has not been found in studies who performed force platform analysis [37,54,55]. Then, walking speed has not been degraded and even improved. More important than triceps sural strength, the good position of the foot may affect the efficiency of the muscle.

In case of initial retraction not allowing to assess the hypertonia, a two-stage surgical procedure could be a solution, by carrying out neurotomies secondarily if a hypertonia is unmasked and there is no impairment due to the loss of propulsive force. As suggested by some authors [52] in case of orthopedic procedure, if the patient presents a residual propulsion preoperatively (e.g. evidenced by a kinetic analysis), the objective would be to preserve the latter as far as possible by performing aponeurotomy techniques (distal aponeurotomy of the gastrocnemius possibly associated with aponeurotomy of the soleus) rather than a calcaneal tendon lengthening.

The evaluation of the motricity of the antagonists is a primordial point which was not systematically realized, as if the absence of tendon transfer was often justified by a preserved function of ankle dorsiflexors. The option of a two-stage surgery has not been mentioned but is a feasible and realistic option allowing an anterior transfer in a second time if some months after the calf neurotomy or lengthening procedure the ankle dorsiflexion is not effective. The realization of a two-stage surgical procedure seems appropriate when the pre-surgical evaluation of the ankle dorsiflexors, after weakening of calf muscles with motor nerve blocks or botulinum toxin, unmasks a motor function but diminished (e.g. limitation of active movement) or when the calf retraction does not allow to carry out such an evaluation and that elements presage of an ankle dorsiflexors function (e.g. activation in swing phase or voluntary

contraction). Such management requires the patient's adherence to ensure that the second surgical time is not perceived as a failure, with the theoretical advantage of avoiding to some patients an unnecessary tendon transfer with its postoperative constraints.

Which muscle to transfer to revive ankle dorsiflexion?

The TA was the most used to perform anterior tendon transfers in EVF, most often justified by the presence of a varus. The new insertion of the (hemi)-TA transferred provides a force direction in valgus on the forefoot either by tenodesis effect or by muscle activation. If it has been shown that there was no change in activation pattern of the transferred muscle [53,56,57], its strength can be decreased, which could not be assessed because the strength testing was usually not performed in the reviewed studies. The significant improvement of ankle dorsiflexion in swing phase after TA transfers [58–61] could be linked to active contraction of TA as well as a passive tenodesis effect. This increase in ankle dorsiflexion amplitude was probably favored by a quasi-systematic lengthening of calf muscles in association with the TA transfers. Three studies reported recurrences of a drop foot [55,62,63] and 8 studies recurrences or persistence of a varus [28–30,55,62,64–66] favored by the weakness of the transferred TA or by the hypertonia of the antagonist muscles (i.e. calf muscles). Recurrences of equinus was rarely reported in alternative transfers but also attributed to calf spasticity [53,62,64]. These findings corroborate the relevance of associating neurotomies of calf muscles to avoid recurrences of an EVF, and on the other hand question the use of a paretic muscle for a transfer.

The transfer of other muscles than TA was a solution retained by several authors, not only because of paresis of TA, but also to take advantage of other hypertonic muscles (such as the FDL [67] or to correct a deformation at the same time such as a claw toes due to the FDL hypertonia [47].

Our scoping review did not show a close link between the choice of the muscle to be transferred and the preoperative clinical data. The TA was chosen in the majority of studies, may be partially due that it was the first transfer described [68] and because the surgical procedure is relatively easy. The TA was often reported to be involved in varus in equino-varus deformity [28,29,48,54,56,59,61,69,70], which is questionable from a biomechanical point of view: when the ankle is in equinus, there is a change in its traction axis increasing its varisant action, and that part of the varus is also due to the action of the calf muscles and peroneus longus [71]. Consequently, equinus deformation seems to be predominant with hypertonia and/or retraction of calf muscles, in association with TA weakness. Even though

the TP was often described as very involved in the occurrence of varus, its lengthening concerned only 20 to 25% of the patients having an anterior tendon transfer in 13/25 studies concerning TA transfers and 4/11 studies concerning alternative transfers. On the other hand, TP was neurotomized in 83% of the cases on 20/23 neurosurgical studies. This discrepancy between neurosurgical and orthopedic approaches may be explained by some factors, knowing that populations of patients are not different except for the greater frequency of calf retractions in orthopedic series. In orthopedic approaches, a TP transfer was often not realized in order to prevent the occurrence of a valgus flat foot [65]. This complication occurred in 5 studies (on overall studies): occurrence of one valgus (0,7%) by a late recovery of peroneal function [28], one case (2%) of hindfoot eversion-forefoot pronation in a serie where all patients had a TP lengthening (can evoke a peroneal action) [63], a valgus with hyperpression on internal side of the foot attributed to a force imbalance after calf muscles neurotomy while peroneal muscles remained active [35], and 32% to 40 % of flat feet or valgus after neurotomy of the TP [41,42]. The participation of the peroneal muscles in the surgical result was not studied while its role has been described in cerebral palsy children in the occurrence of valgus foot [72] and the implication of the peroneus longus in foot pronation and varus was described [71]. Two studies [73,74] did not showed any link between the occurrence of flat feet and TP transfer but pes cavus was noticed in one [73]. The same observation was made in the surgeries of drop foot after peroneal palsy [75–77]. Others arguments in favor of the involvement of TP in deformity is the occurrence of recurrence when it was not weakened (neurotomy or lengthening) during the surgery [28,55,62,66,78].

Based on our review, equinus management is the first step. If equinus is mostly spastic, selective neurotomies are preferred. In presence of retraction, a lengthening must be performed. The association of the two techniques is not yet well studied. In the case of sequential surgery, it is essential to perform a close follow-up to monitor recurrences. FDL/FHL tenotomy should be quasi systematic.

In presence of varus, a lengthening or neurotomy of the TP and/or LFH can be performed if they are involved. Finally, a tendon transfer can be done in first intention if ankle dorsiflexors are deficient, or in a second step if it persists a doubt on their effectiveness. The choice of tendon to be transferred should favor a non-paretic muscle, possibly involved in the deformation (modification of its biomechanical Even if the TA was the most used in the literature, no argument can reject the use of other muscles to achieve the transfer.

Place of arthrodesis

Although we have integrated osteo-articular procedures into our search strategy, very few studies have been found, particularly none concerning the use of osteotomies (e.g. calcaneal osteotomy to correct hindfoot varus). It can be explained by the lack of originality of these techniques apart from the specific indication for spastic EVF, and the higher risk of post-operative complications. Arthrodesis aims to reduce pain, stabilize and correct a deformity of the foot or ankle, but could be associated with long-term arthroses' adjacent joints [79]. When arthrodesis respected the talocrural joint, spasticity assessment was considering, unlike muscular strength, and the best results were observed when there was a balance between plantar and dorsal flexors. If dorsiflexors are deficient, tendinous transfer must be associated to allow the correction of the foot drop [80].

What functional improvement is provided by surgery?

The most frequently reasons forwarded to perform surgery of EVF were to improve autonomy and/or to stop orthoses or technical aids. In neurotomies' studies, 7/13 studies did not showed improvement in walking speed, and 5/6 studies found an improvement of the autonomy without systematic stop of the technical aids. In studies on tendon transfers, 7/11 studies reported an improvement in walking speed, not systematically exposed with a statistical analysis. Autonomy was improved in all studies that report it, but stopping orthoses was not systematic (65 to 73%). The aids withdrawal and autonomy are facilitated if there is a better final motor state [29,47,53,63,81] suggesting that the postoperative (and therefore preoperative) motor state is an indirect marker of the functional result. In order to limit the functional impact of the weakening of the TS following the lengthening of the calcaneal tendon or when TS was paretic [47], some authors performed a transfer of FDL on the calcaneus, in addition to the split TA transfer or to the anterior transfer of FHL. A better autonomy and more orthoses withdrawal were reported with this technic [53]. An alternative would be to perform a gastrocnemius aponevrotomy instead of calcaneal lengthening to limit the loss of strength of the triceps surae [82].

A common objective of surgeries was to improve autonomy by restoring a better positioning of the foot in the stance phase (i.e. plantigrade support), which provides a better stability and allows a good initiation of the swing phase contributing to walking autonomy. Whatever the type of surgery, this outcome seems to have been reached. Consequently, we find that according to the judgment criterion used to evaluate the surgery, the discussion around the choice of the most appropriate surgical procedure may seem superfluous. Indeed, a global approach based on correcting deformations by standard techniques could be effective and do

not need a full presurgical assessment. On the other hand, a more individual approach allow to select the procedure according to specific objectives such as the weaning of orthosis or keeping a propulsion force.

Suggestions for a personalized surgery according to a standardized approach

We suggest a systematic evaluation procedure before any EVF surgery in order to better indicate the relevant surgical techniques and to ensure a complete and relevant functional assessment:

1- Assessment of deformations' reducibility based on clinical assessment of passive range of motion of ankle dorsiflexion knee extended and flexed, mobility and alignment of hindfoot, midfoot and forefoot, claw toes fixed or not. A complementary imaging assessment can complement the clinical approach.

2- Assessment of motor function of ankle muscles with analytical testing based on Held scoring well suited to central paresis [1], ankle dorsiflexor selective motor control using Boyd scale [83] for example, possible limitation of active range of motion [84], muscle activation during gait with dynamic EMG or visual gait analysis based on tendon observation (e.g. TA tendon).

3- Assessment of muscle hypertonia consisting of the assessment of calf muscles spasticity (MAS or Tardieu score) and of spastic cocontractions with dynamic EMG or visual gait analysis based on deformations observation (e.g. claw toe).

4- Kinematic gait analysis if possible, allowing to characterize foot and ankle positions at different stages of gait cycle, and to have a more global view of the gait pattern at the overlying level (knee, hip, pelvis and trunk).

5- Kinetic gait analysis if possible, allowing to quantify propulsion at the ankle level, and to determine spatiotemporal gait characteristics.

6- Assessment of walking capacities on functional test (functional ambulation categories or FAC) and may be completed by performance test (Six minute walk test or Ten meter walk test) [85].

All those elements should be reassessed after a possible selective motor nerve block or botulinum toxin injection. These clinical and instrumental evaluations are linked to the patient's complaints and his surgical goals assessed with a standardized procedure such the Goal Attainment Scale [86]. This systematic evaluation allows to obtain all the elements necessary to the choice of the surgical techniques and to evaluate the contribution of the

surgery to the requests of the patient.

Limits

Despite the respect of a PRISMA methodology, this scoping review suffers from the limitations of the studies collected given that the majority of studies were retrospectives and non-comparatives with a very incomplete description of population characteristics. The quality of the studies according to the MINORS criteria was poor, the low score being often linked to the lack of prospective nature of the studies and the absence of instrumental objective judgment criteria. The use of subjective or clinical criteria was not offset by the implementation of a blinded evaluation. The criteria for judgments were often subjective or involved only one examiner, and the retrospective design did not guarantee the completeness of the collection of recurrences and side effects. Our results regarding preoperative indications must therefore considering this major selection bias, and the questions raised about the results during the discussion should be balanced by the judgmental bias of the studies.

Conclusions

EFV surgeries in the brain injured adults are common and reported in many studies. Yet none of them permit to identify recommendations in order to standardize surgical procedures. We propose a standardized evaluation procedure to identify the many mechanisms involved in the deformity, but also the functional impact of the EVF on the walking function and in the patient's life. Such a standardized pre-operative and post-operative approach could better meet patients' expectations by offering more personalized surgeries, limiting the number of recurrences.

A cohort analysis with a standardized pre- and post-operative clinical examination combined with a multimodal evaluation of the effectiveness of the surgery would answer many questions. Another perspective would be to provide an expert consensus using an analytic hierarchy process and then the non-consensual points could be the subject of comparative prospective studies.

Figure 1. Flow diagram

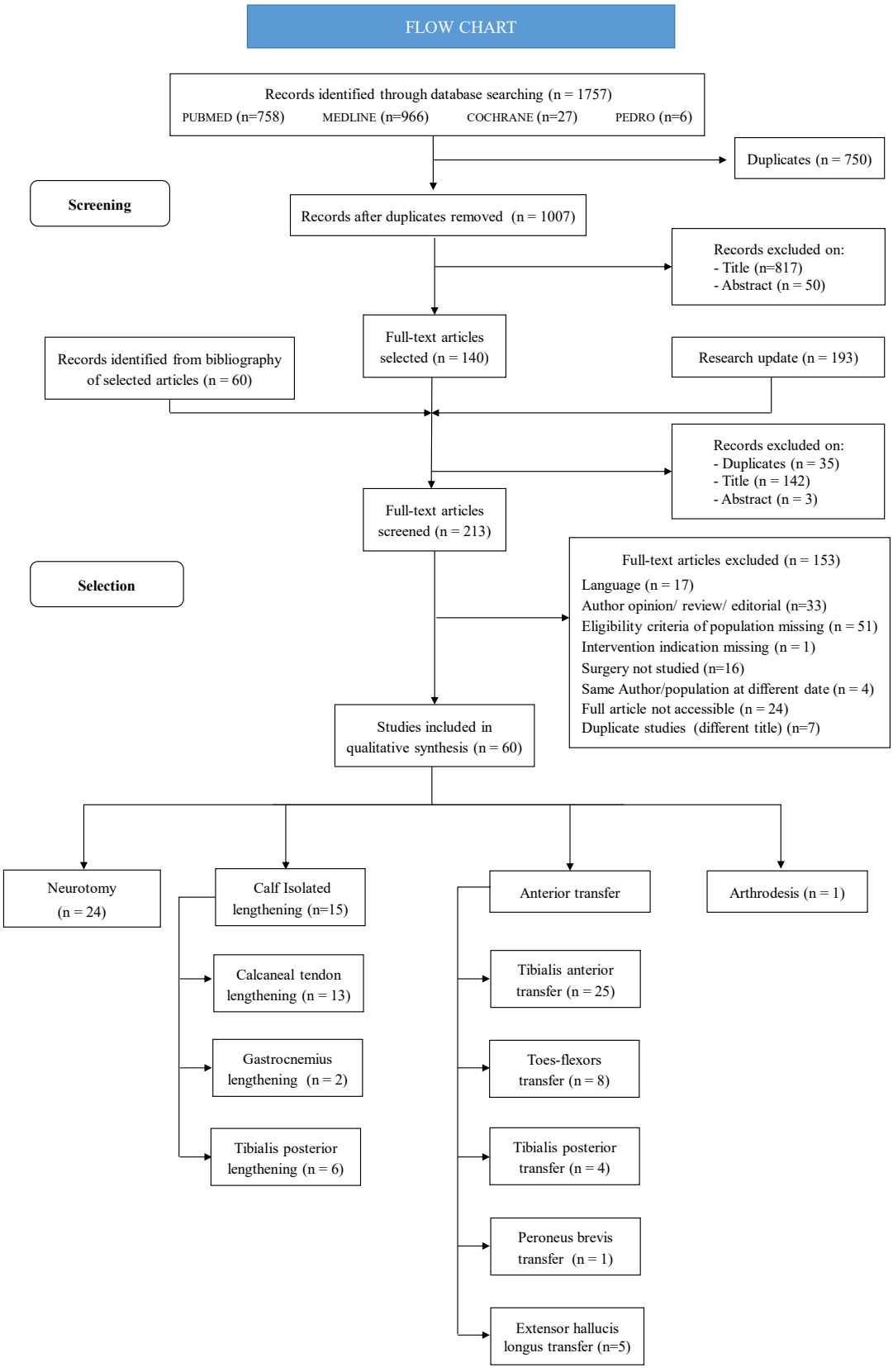

Table 1. Neurotomy of calf muscles: type of study, population characteristics and details of surgeries**.**

Authors **Date**	**EBM**	**Type of study**	**MINORS**	**Pathology**			**N**	**Age** [range] or (SD), y	**Delay** [range], m	**Number** (% of total)					**Additional surgery:** Number associated with STN (%)
				Stroke	**TBI**	**Others**				**SOL** *Or when specified* **TN/ UNS/ LNS**	**GM**	**TP**	**FDL**	**FHL**	
Bollens et al. 2013	I	RCT	20	8			8	50 [32-70]	30 [8-83]	8 (100)		5 (63)		5 (63)	
Buffenoir et al. 2004	III	P, CS	9	34	8	13	55	44 [12-74]	64 [3-320]	55 (100)	-	39 (71)	36 (65)	28 (51)	
Rousseaux et al. 2009	III	P, CS	12	51			51	51 (12)	44 [11-304]	51 (100)	50 (98)	27 (53)	10 (20)	-	
Decq et al. 2000	III	P, CS	12	18	15	13	46	36 [8-79]	96	**UNS** 46 (100) ± **LNS** 21 (46)	9 (20)	18 (39)	17 (37)	16 (35)	GM-apo 4 (9) if ADF<0°
Rousseaux et al. 2008	III	P, CS	12	34			34	50 (12)	45 [7-293]	34 (100)	34 (100)	27 (79)	10 (29)		
Deltombe et al. 2015	III	P, CS	12	25	5		30	45 [20-69]	48 [15-218]	30 (100)	16 (53)	26 (87)		22 (73)	
Le Bocq et al. 2016	III	P, CS	8	23			23	57 [48-63]	28 [9-133]	23 (100)	23 (100)	10 (43)			
Deltombe et al. 2018	III	P, CS	11	18			18	56 (11)	> 6	12 (67)		7 (39)		11 (61)	GM-apo: 6 (50) CT-l: 2 (16) FDL-l: 7 (58)
Buffenoir et al. 2013	III	P, CS	12	9	4	2	15	47 [22-66]	86 [12-424]	**UNS** 15 (100) ± **LNS** 10 (67)	**GML** 3 (20)	9 (60)	7 (47)	7 (47)	
Deltombe et al. 2008	III	P, CS	9	10	1		11	51 [38-57]	-	11 (100)	9 (82)	10 (91)		8 (73)	
Buffenoir et al. 2008	III	P, CS	7	4	2	1	7	41 [19-71]	37 [10-45]	**UNS** 7 (100) ± **LNS** 5 (71)		7 (100)	5 (71)	6 (86)	
Abdennebi & Bougatene 1996	III	R, CS	4	6	4	48	66	24 [5-65]	> 12	66 (100)	66 (100)	29 (44)	10 (15)		
Sindou et al. 1988	III	R, CS	5	19	14	20	62	36 [6-68]	48 [24-204]	58 (94)	58 (94)	45 (72)	38 (61)	38 (61)	
Sindou et al. 1985	III	R, CS	2	25		14	47	35 [6-68]	-	-	-	-	-		
Palacio et al. 2010	III	R, CS	7	18	7		25	Age of accident: 38 [3-68]	62 [6-444]	23 (92)	24 (96)	1 (4)			TP-l: 8 (32) Bardot: 11 (44) FDL-l: 7 (28) FHL-l: 6 (24) Tenodesis EHL & TA: 1 (4) Talonavicular arthrodesis: 1 (4)
Kim et al. 2010	III	R, CS	5	5	7		13	31 [17-51]	> 12	Branch of posterior tibial nerve	-	-	-	-	
Fève et al. 1997	III	R, CS	5	6	5	1	12	36 (15)	53 (22)	12 (100)	12 (100)				
Caillet et al. 1998	III	R, CS	7	9			9	[25-69]	> 12	-	-	-	-	-	
Roujeau et al. 2003	III	R, CS	10	1	2	3	7	28 (13)	67 [8-144]	**UNS** 7 (100)		1 (14)	2 (29)	2 (29)	
Collado et al. 2006	III	R, CS	4	2	2		4	35 [6-62]	>12	**SOL**: 2 (50) or **TN:** 2 (50)	1 (25) (with STN SOL)	1 (25) (with STN SOL)			
Deltombe et al. 2006	III	R, CS	7	3			3	54 [45-69]	23 [15-30]	3 (100)	3 (100)	2 (67)		3 (100)	
Bleyenheuft et al. 2008	III	R, CS	7	2			2	47 & 68	16 & 32	**UNS** 2 (100) ± **LNS** 1 (50)					GM-apo: 1 (50) (with UNS+LNS STN)
Bensoussan et al. 2010	III	CR	6	1			1	44	53	1 (100)	1 (100)				
Jang et al. 2004	III	CR	4		1		1	37	21	1 (100)	1 (100)	1 (100)			

Abbreviations: CR, case report; **CS**, case serie; **CT**, calcaneal tendon; **EBM**, Evidence Base Medicine; **EHL**, extensor hallucis longus; **FDL** flexor digitorum longus; **FHL** flexor hallucis longus/brevis; **GM (M or L)**, gastrocnemius (medial or lateral); **MINORS**, Index for Non-Randomized Studies: score on 24 for type I & II, score on 16 for type III; **N,** number of feet operated in the study; **P/R**, prospective/retrospective study; **RCT**, randomized controlled study; **SD**, standard deviation; **TA**, tibialis anterior; **TBI** traumatic brain injury; **TP**, tibialis posterior; **X-apo/-l/-t/-r**, muscle aponevrotomy/lengthening/transfer/release; **I**, randomized controlled study; **II**, comparative study (retrospective or prospective); **III**, case series (retrospective or prospective)

Table 2. Neurotomy of calf muscles: presurgical clinical and instrumental criteria.

Authors Date	**PROM**		**Motricity** *(Scale)*				**Spasticity** *(Scale)*	**Dynamic muscle activation** (EMG or Visual)	**Kinematic gait analysis**			**NB or BTI** (% of population)	**Response to nerve block**
	ADF-KE	ADF-KF	**Strength** (MRC) ADF	APF	Motor control	AROM			Instrumental (I) or visual (V)	Lack of ADF in SwP?	Dynamic varus ?		
Bollens et al. 2013	<0°	>0°	≥3	<3			X (MAS/TAR)		X *(I)*	X		NB / 100%	X / needed
Buffenoir et al. 2004	<0°	>0°			X		X (TAR/Cl)						
Rousseaux et al. 2009	≥ 0°		<3	<3		<0° ADF	X (MAS/Cl)					BTI, NB / 100%	X / needed
Decq et al. 2000	>0°				X		X (MAS/TAR)		X *(I)*			NB	
Rousseaux et al. 2008	≥ 0°		<3	<3		<0°	X (MAS/Cl)					BTI±NB / 100%	X / needed
Deltombe et al. 2015	≥ 0°	≥ 0°	≥3	≥3			X (ASH)		X *(I)*	X	X	NB / 100%	X / needed
Le Bocq et al. 2016	<0°	≥ 0°	<3	<3			X (MAS)		X *(V)*	X	X	NB	X / needed
Deltombe et al. 2018	<0°		<3	<3		<0°	X (MAS/TAR)		X *(I)*	X		NB / 100%	
Buffenoir et al. 2013	≥ 0°						X (MAS/TAR)		X *(V)*			BTI, NB / 100%	X / needed
Deltombe et al. 2008	≥ 0°			≥3			X (ASH)		X *(I)*		X	NB / 100%	X / needed
Buffenoir et al. 2008	≥ 0°	≥ 0°			X		X (TAR)	X (EMG)	X *(I)*	X		NB / 100%	
Abdennebi & Bougatene 1996	Not retracted (no fixed deformities)				X		X (ASH/Cl)					NB	X / needed
Sindou et al. 1988	≥ 0°		<3	<3			X (ASH/ Cl)					NB, curare / 27%	X / needed
Sindou et al. 1985							X						
Palacio et al. 2010							X (ASH/ Cl)					NB / 76%	
Kim et al. 2010	≥ 0°						X (ASH/ Cl)						
Fève et al. 1997	≥ 0°			≥3	X	<0°	X (TAR)					NB / 100%	X / needed
Caillet et al. 1998	<0°				X		X (MAS)	X (EMG)	X *(I)*	X			
Roujeau et al. 2003	≥ 0°				X		X (TAR)		X *(V)*			NB / 50%	X
Collado et al. 2006	<0°	<0°					X (ASH/ Cl)		X *(V)*			NB, BTI / 75%	X
Deltombe et al. 2006	≥ 0°						X (ASH)		X *(I)*			NB	X
Bleyenheuft et al. 2008	≥ 0°	≥ 0°	≥3	<3			X (TAR/Cl)					NB	X
Bensoussan et al. 2010	<0°	<0°					X (MAS/Cl)		X *(V)*		X	BTI / 100%	X
Jang et al. 2004	<0°		<3				X (MAS)					Phenol / 100%	X

Abbreviations: ADF-KE/KF ankle dorsiflexion knee extended/knee flexed; **APF** ankle plantar flexion; **AROM** active range of motion; **ASH** Ashworth; **BTI** botulinum toxin injection; **Cl** Clonus; **PROM** passive range of motion; **MAS** Modified Ashworth scale; **NB** nerve block; **SwP** swing phase; **TAR** Tardieu scale

Table 3. Calf muscles lengthening: type of study, population characteristics and details of surgeries.

Authors Date	**EBM**	**Type of study**	**MINORS**	**Population**			**N**	**Age** (y)	**Delay** (m)	**Type of lengthening:** number of surgeries (% of total)			**Additional surgeries:** Number associated with CT-l or GM-apo, (%)		
				Stroke	**TBI**	**Others**				**CT-l**	**GM-apo**	**FDL**	**TP-l**	**FDL or FHL or FDB release/ lengthening**	**Other**
Deltombe et al. 2018	III	P, CS	11	18			18	56 (11)	> 6	4 (22)				FHL-l: 3 (75) FDL-l: 4 (100)	
Takahashi et Shrestha 2002	III	R, CS	4	230			230	68 [46-78]	[3-6]		230 (100)		preserved even if varus/retraction	FDL/FHL-l: -	
Carda et al. 2009	III	R, CS	7	177			177	50 (14)	67 (90)	52 (29)			X (rearfoot varus) (-)	FDL-l: -	
Mooney & Goodman, 1969	III	R, CS	1	122			122	55 [17-84]	-	40 (33)			X (rearfoot varus) (-)	40 (100)	
Lee & Ko 2005	III	R, CS	7	18			25	40 [23-64]	> 12	25 (100)					
Yamamoto et al. 1992	III	R, CS	10	75			75	57	18		21 (28)	5 (6)		FDL-l: 16 (76)	
Barouk, 1989	III	R, CS	0		35		49	24 [17-45]	[12-24]	14 (29)				FD-r: -	
Roper et al. 1978	III	R, CS	3	37			37	43 [18-72]	-	14 (38)			X (hindfoot varus) (-)	FDL-l: -	
Fried 1961	III	R, CS	0	8			8	Elderly	-	8 (100)			8 (100)	FDL/FHL-l: 8 (100)	
Giannotti 2016	III	R, CS	7	47			47	56 (15)	72 (60)	12 (25)				FDB-r: 5 (42) FDL/FHL-l :5 (42)	
Giannotti et al 2018	III	R, CS	8	24			24	55 [29-74]	60 (36)	6 (25)				FD-r: 6 (100)	
Redfern et Thordarson 2008	III	R, CS	4	1		5	6	59 [55-73]	76 [7-180]	6 (100)			6 (100)		
Waters et al, 1982	III	R, CS	7	20	5	2	27	[22-68]	>6	4 (15)				FDL/FHL-r: 4 (100)	
Benedetti 2011	III	R, CS	6	11	2		13	51 [19-74]	-	2 (15)				FDL-r: 2 (100) FHL-r: 1 (50)	
Boffeli et Collier 2014	III	CR	5	1			1	61	144	1 (100)			1 (100)	FDL/FHL-l: 1 (100)	

Abbreviations: CR, case report; **CS**, case serie; **CT**, calcaneal tendon; **EBM**, Evidence Base Medicine; **FDL/FDB**, flexor digitorum longus/brevis; **FHL/FHB**, flexor hallucis longus/brevis; **GM (M or L)**, gastrocnemius (medial or lateral); **MINORS**, Index for Non-Randomized Studies: score on 24 for type I & II, score on 16 for type III; **N,** number of feet operated in the study; **P/R**, prospective/retrospective study; **SD** standard deviation; **TBI** traumatic brain injury; **TP**, tibialis posterior; **X-apo/-l/-t/-r**, muscle aponevrotomy/lengthening/transfer/release; **I**, randomized controlled study; **II**, comparative study (retrospective or prospective); **III**, case series (retrospective or prospective).

Table 4. Calf muscles lengthening: presurgical clinical and instrumental criteria.

Authors Date	**PROM showing equinus** (Fixed contracture or negative values)	**Motricity** (Scale)				**Spasticity** (Scale)	**Dynamic muscle activation** (EMG or Visual)	**Kinematic gait analysis**			**NB or BTI**	**Motivation of the surgery**
		Strength		**Motor control**	**AROM**			Instrumental (I) or Visual (V)	Lack of ADF in SwP?	Dynamic varus?		
		ADF	APF									
Deltombe et al. 2018	X	ADF weak (MRC)	APF weak (MRC)		AROM<0°	X (TAR/MAS)		X (I)	X		TN branch for all	
Takahashi & Shrestha. 2002				Minimal synergic control (BRS)		X (BRS)		Gait analysis often done (NS)				FDL/FHL-l if claw toes TP preserved even if retracted or rear-foot varus to maintain stability
Carda et al. 2009	X					Exclude		X (I)	X			TP-l if rear-foot varus FDL-l if claw toes
Mooney & Goodman. 1969	equinus: fixed or spastic					± spastic						FDL-l if claw toes TP-l if rear-foot varus
Lee & Ko. 2005	X					X						
Yamamoto et al. 1992	equinus			Minimal synergic control (BRS)		X (BRS)						FDL-l if claw toes
Barouk, 1989	Describe only results											
Roper et al. 1978	X				AROM-KF>0°	X					TN	FDL-l if claw toes TP-l if rear-foot varus, in SwP not only due to TA activity
Fried et al.1961	equinus					X						
Giannotti et al. 2016						Exclude		X (I)	X			
Giannotti et al. 2018						Exclude		X (I)	X			
Redfern et Thordarson. 2008	X											
Waters et al. 1982	Equinus					X (CL)	EMG					
Benedetti et al. 2011								X (I)	X	X		
Boffeli et Collier. 2014	X					X		X (V)				

Abbreviations: ADF-KE/KF ankle dorsiflexion knee extended/knee flexed; **APF** ankle plantar flexion; **AROM** active range of motion; **ASH** Ashworth; **BRS** Brunnstrom scale; **BTI** botulinum toxin injection; **Cl** Clonus; **FDL** flexor digitorum longus; **FHL** flexor hallucis longus; **PROM** passive range of motion; **MAS** Modified Ashworth scale; **NB** nerve block; **SwP** swing phase; **TAR** Tardieu scale; **TA** tibialis anterior; **TN** tibial nerve

Table 5. Tibial anterior transfer: type of study, population characteristics, details of surgeries.

Authors Date	**EBM**	**Type of study**	**MINORS**	**Population**			**N**	**Age** (y) [range] or (SD), y	**Delay** (m) [range] or (SD), y	**Type of transfer** (SPLATT if not precised), number of surgeries (% of total)	**Insertion**	**Additional surgeries:** Number associated with transfer (%)						
				Stroke	**TBI**	**Others**						**Posterior lengthening** (CT-l if not precised)	**FHL/FDL-l**	**FHB/FDB-r (PFR)**	**TP-l &/or EHL-l**	**Complementary anterior transfer**	**FDL-t to calcaneum**	**Arthrodesis**
Keenan et al, 1999	I	RCT	20	22	28	5	67	38 [11-80]	32 [17-53]	67 (100)	Cb	67 (100)		67 (100)	TP 28 (42) EHL 12 (18)		36 (54)	
Pinzur et al, 1986	II	R - Cp	9	31	16	7	54	43 [17-77]	38 [12-204]	54 (100) - TA	Cm/Cl	54 (100)	54 (100)	42 (78)	TP 12 (22)			
Hosalkar et al, 2008	II	R - Cp	15		47		47	43 [29-67]	31 [18-66]	47 (100)	Cb	-	FD-r **(-)** *+(PFR)*		TP (-)	**EHL** (-)	(-)	
Carda et al, 2010	II	R - Cp	17	29			29	50 [20-67]	61 [14-123]	15 (52)	Cb	15 (100)	15 (100)					
Deltombe et al, 2018	III	P - CS	11	18			18	56 (11)	> 6	2 (11)	Fb	1 (50) 1 (50) - GM	FDL 2 (100) FHL 1(50)					
Vogt et al, 2011	III	R - CS	7	80	25	25	132	47 [11-78]	79 [13-486]	132 (100)	Cb	129 (98)		118 (89)	TP 4 (3) EHL 12 (9)		1 (1)	1 (1)
Mooney & Goodman, 1969	III	R - CS	1	122			122	55 [17-84]	-	84 (69)	Cl	82 (98)		84 (100)	TP (-)			
Vogt et al, 1998	III	R - CS	8	42	15	12	73	47 [8-79]	50	73 (100)	Cb	58 (79)		55 (75) (6 w/o CT-l)	TP 1 (1)			
Namdari et al, 2009	III	R - CS	9	64			64	54 [24-74]	66 [17-523]	64 (100)	Cb/Cl	58 (91)		PFR 56 (88)	TP 30 (47) EHL 7 (11)	**EHL** 39 (61)	61 (95)	
Keenan et al, 1984	III	R - CS	8		54		59	25 [14-50]	35 (26)	59 (100)	Cb/Cl	53 (90)	FDL 52 (88)/ FHL 34 (58)		TP 1 (2)	**FHL** 18 (31)		
Tracy et al, 1976	III	R - CS	6	22	8	5	35	40 [18-62]	46	35 (100)	Cl	35 (100)		35 (100)	TP 35 (100)			
Carda et al, 2009	III	R - CS	7	177			177	50 (14)	67 (90)	33 (19)	Cb	33 (100) CT or GM	33 (100)				(-)	
Lemos et al, 2011	III	R - CS	8	21	6		27	49 [18-72]	84 [24-64]	27 (100)	Cb	27 (100)	26 (96)		TP (-)			
Reddy et al, 2008	III	R - CS	9	26			26	55 [23-72]	74	26 (100)	Cb	26 (100)		26/100%	TP (-)	**EHL** (-)	26 (100)	
Edwards et al, 1993	III	R - CS	7	9	9	3	24	41 [18-67]	34	24 (100)	Cb	23 (96)	21 (88) /PFR 3 (12)		TP 5 (21)	**FHL-t** 4 (17)		2 (8)
Waters et al, 1982	III	R - CS	7	20	5	2	27	[22-68]	> 6	23 (85)	-	23 (100)	12 (52)			**FDL/ FHL** 10 (43) **TP** 1 (4)		
Roper et al, 1978	III	R - CS	3		37		37	43 [18-72]	-	23 (62)	Cm	23 (100)		X (-)	TP (-)			
Martin et al, 1989	III	R - CS	3		17	6	23	37 [13-64]	48 [6-336]	23 (100)	Cb/Fb	19 (83)		20 (87)				
Gasse et al, 2012	III	R - CS	2	14	4	4	22	40 [17-76]	-	22 (100)	M5	22 (100) CT or GM						
Morita et al, 1998	III	R - CS	9	125			125	61 [42-78]	23 [6-132]	15 (12) - TA	Cl	15 (100) GM	15 (100)	3 (20)				
Giannotti et al, 2016	III	R - CS	7	47			47	56 (15)	72 (60)	10 (21)	-	10 (100)		10 (100)		**FHL** 10 (100)		
Giannotti et al, 2018	III	R - CS	8	24			24	55 (13)	60 (36)	9 (38)	-	9 (100)		9 (100)		**FHL** 3 (30) **EHL** 1 (w/ 1 FHL-t)		
Barouk et al, 1989	III	R - CS	0		35		49	24 [17-45]	[12-24]	8 (16)	Fb	8 (100)		X (-)				
Benedetti et al, 2011	III	R - CS	6	11	2		13	51 [19-74]	-	6 (46) 2 (15) - TA	-	6 (75)		FDL 4 (50) FHL 2 (25)	TP 1 (12)			
Yamamoto et al, 1992	III	R - CS	10	75			75	57	18	5 (7) - TA	-	5 (100) GM		5 (100)				

Table 5 (second part). Tendon anterior transfer (except SPLATT): type of study, population characteristics, details of surgeries**.**

Authors Date	**EBM**	**Type of study**	**MINORS**	**Population**			**N**	**Age** [range] or (SD), y	**Delay** [range], m	**Transfers**						**Additional surgeries:** Number associated with transfer (%)				
				Stroke	**TBI**	**Others**				**FDL/FHL**	**EHL**	**TP**	**Bardot**	**Number of transfer** (% of total)	**Insertion**	**CT-l**	**GM-apo**	**FDL/FHL-l**	**FDB/FHB-r**	**Others**
Carda *et al.* 2010	II	R - Cp	17	29			29	51 [32-70]	82 [19-164]		14			14 (48)	M4	14 (100)			14 (100)	
Morita *et al.* 1998	III	R - CS	9	125			125	57 [32-75]	23 [6-132]	FDL/FHL 110				110 (88)	M4		110 (100)		15 (14)	TP-l: 8 (7)
Carda *et al.* 2009	III	R - CS	7	177			177	50 (14)	67 (89)	FHL 13	71			84 (47)	M4 or M3	84 (100)		84 (100)		FDL-t to calcaneum: NS TP-l: NS
Yamamoto *et al.* 1992	III	R - CS	10	75			75	57	18	FDL 41		3		44 (59)	-		44 (100)			
Curvale *et al.* 1999	III	R - CS	7	30	8	3	41	46 [27-76]	NS				41	41 (100)	Fb	41 (100)		FHL 41	41 (100)	
Ono *et al.* 1980	III	R - CS	4	32	1	6	39	Adults	> 12	FDL/FHL 39				39 (100)	M4		39 (100)			
Morita *et al.* 1994	III	R - CS	7	29			29	58 [40-70]	29 [6-85]	FDL/FHL 29				29 (100)	M4	29 (100)			3 (10)	TP-l: 5 (17)
Gasq *et al.* 2013	III	R - CS	7	16	4		20	52 [22-66]	102 [20-271]			20		20 (100)	Cl	20 (100)		FHL 5	12 (60)	
Giannotti *et al.* 2016	III	R - CS	7	47			47	56 (15)	72 (60)	FHL 11	14			25 (53)	M4 for EHL	25 (100)			25 (100)	With FHL-t: TP-l: 2 (8) FDL-t to calcaneum: 5 (20)
Sturbois-Nachef *et al.* 2018	III	R - CS	9	5	3	5	13	43 [30-61]	65 [12-108]			13			TA or PB or Cb	10 (77)	1 (8)	FDL 4 (31) FHL 1		STN-GM : 11 (85) STN-UNS : 11 (85) STN-TP: 4 (31)
Giannotti *et al.* 2018	III	R - CS	8	24			24	55 (13)	60 (36)	FHL 5	1			6 (25)	M4 (EHL)	6 (100)			6 (100)	
Wagenaar and Louwerens 2007	III	R - CS	8	5			5	38 [16-59]	96 [12-336]			5		5 (100)	TA & PT or EDL	5 (100)			1 (20)	Triple arthrodesis: 1 (20) EHL-t: 1 (20)
Benedetti *et al.* 2011	III	R - CS	6	11	2		13	51 [19-74]	NS	FDL 1	2			3 (23)	-	3 (100)			2 (67)	TP-l: 1 (33)

Abbreviations: - not precised/not signified; [range] or (SD), y; **Cb** cuboid; **Cl/Cm** cuneiform lateral/medial; **Cp** comparative; **CR** case report; **CS** case serie; **CT** calcaneal tendon; **EBM** Evidence Base Medicine; **EDL** extensor digitorum longus; **EHL** extensor hallucis longus; **Fb** fibular brevis; **FDL/FDB**, flexor digitorum longus/brevis; **FHL/FHB**, flexor hallucis longus/brevis; **GM (M or L)** gastrocnemius (medial or lateral); **MINORS** Index for Non-Randomized Studies: score on 24 for type I & II, score on 16 for type III; **M4 or M3** 4th or 3rd metatarsus; **N** number of feet operated in the study; **PFR** plantar fascia release; **P/R** prospective/retrospective study; **PT** peroneus tertius; **RCT** randomized controlled study; **SD** standard deviation; **SPLATT** split anterior tibialis tendon transfer; **TA** tibialis anterior; **TBI** traumatic brain injury; **TP** tibialis posterior; **X-apo/-l/-t/-r** muscle aponevrotomy/lengthening/transfer/release; **I** randomized controlled study; **II** comparative study (retrospective or prospective); **III** case series (retrospective or prospective)

Table 6. Tibial anterior transfer: presurgical clinical and instrumental criteria.

Authors Date	**PROM showing equinus** (*Fixed contracture or negative values*)	**Motricity** *(Scale)*				**Spasticity** *(Scale)*	**Dynamic muscle activation** (EMG or Visual)	**Kinematic gait analysis**			**NB or BTI**	**Varus indicates surgery**
		Strength		**Motor control**	**AROM**			Instrumental (I) or Visual (V)	Lack of ADF in SwP?	Dynamic varus ?		
		ADF	APF									
Keenan et al, 1999						X	X (EMG)	X (I but ND)				
Pinzur et al, 1986						X	X (EMG)	X (I)	X	X	TN phenol insufficient	X
Hosalkar et al, 2008							X (EMG)					
Carda et al, 2010	X					Exclude	X (EMG or Visual)	X (I)	X	X		
Deltombe et al, 2018	X	TA weak (MRC)	TS weak (MRC)		AROM <0°	X (TAR/MAS)	X (Visual)	X (I)	X		NB systematic	
Vogt et al, 2011				Distal muscular control (Visual)		X		X (V)				
Mooney & Goodman, 1969	X					X						X
Vogt et al, 1998												X
Namdari et al, 2009	No bone deformation					X	X (EMG)	X (V)				
Keenan et al, 1984							X (EMG)					
Tracy et al, 1976								X (V)	X	X		
Carda et al, 2009	X					Exclude		X (I)	X			X
Lemos et al, 2011							X (Visual)					X
Reddy et al, 2008						X	X (EMG)					X
Edwards et al, 1993	X						X (EMG)					
Waters et al, 1982						X (Cl)	X (EMG)					X
Roper et al, 1978	X					X		X (I but ND)			NB	
Martin et al, 1989				Strong contraction of TA (in triple flexion) (Visual)			X (EMG)					X
Gasse et al, 2012	X											
Morita et al, 1998				Minimal synergic control (BRS)		X (BRS)	X (Visual)					
Giannotti et al, 2016						Exclude		X (I)	X			
Giannotti et al, 2018						Exclude		X (I)	X			
Barouk et al, 1989												
Benedetti et al, 2011								X (I)	X	X		
Yamamoto et al, 1992				Minimal synergic control (BRS)		X (BRS)	X (Visual)					X

Table 6 (second part). Tendon anterior transfer (except SPLATT): presurgical clinical and instrumental criteria**.**

Authors Date	**Type of transfer**	**PROM showing equinus** (*Fixed contracture or negative values*)	**Motricity** *(Scale)*				**Spasticity** *(Scale)*	**Dynamic muscle activation** *(EMG or Visual)*	**Kinematic gait analysis**			**NB or BTI**	**Motivation of the surgery**	
			Strength		**Motor control**	**AROM**			*Instrumental (I) or Visual (V)*	Lack of ADF in SwP?	Dynamic varus?		**Precisions**	**Varus indicates transfer**
			ADF	APF										
Carda et al. 2010	EHL	X					Exclude	X (EMG or V)	X (I)	X	X		alternative of TA when no TA activity	X
Morita et al. 1998	FDL/FHL				Minimal synergic control (BRS)		X (BRS)						alternative of TA to avoid paresis & foot drop	
Carda et al. 2009	FHL/EHL	X					Exclude		X (I)	X			correct varus with EHL-t/ using FHL as dorsiflexor	X
Yamamoto et al. 1992	FDL/TP				Minimal synergic control (BRS)		X (BRS)	X (V)					correct varus (& claw toes when FDL)	X
Curvale et al. 1999	Bardot	X	TA ≥4 (MRC) No fibular activity		TA ≥4 in triple flexion		X	X (V)	X (V)	X	X		revive eversion	
Ono et al. 1980	FDL/FHL				Minimal synergic control Motricity of FDL needed		X	X (EMG or V)						
Morita et al. 1994	FDL/FHL												revive dorsiflexion (active or tenodesis effect)	
Gasq et al. 2013	TP	X	ADF weak No fibular activity				X	X (V)					alternative of SPLATT (surgery not possible)	
Giannotti et al. 2016	FHL/EHL						Exclude		X (I)	X				
Sturbois-Nachef et al. 2018	TP							X (V)					Correct hindfoot varus not due to TA	X
Giannotti et al. 2018	FDL/EHL						Exclude		X (I)	X				
Wagenaar and Louwerens 2007	TP		ADF weak (MRC)	TP ≥ 4+ (MRC)			X		X (V)	X	X			
Benedetti et al. 2011	EHL								X (I)	X	X			

Abbreviations: ADF-KE/KF ankle dorsiflexion knee extended/knee flexed; **APF** ankle plantar flexion; **AROM** active range of motion; **ASH** Ashworth; **BRS** Brunnstrom scale; **BTI** botulinum toxin injection; **Cl** Clonus; **EHL** extensor hallucis longus; **FDL** flexor digitorum longus; **FHL** flexor hallucis longus; **PROM** passive range of motion; **MAS** Modified Ashworth scale; **NB** nerve block; **ND** not detailed; **SwP** swing phase; **TA** tibialis anterior; **TAR** Tardieu scale**; TN** tibial nerve; **TP** tibialis posterior

Supplemental results

Neurotomy of calf muscles

Twenty-four studies (523 patients) reported neurotomy of calf muscles. Type of study, population characteristics and details of neurotomy surgeries were detailed in **Table 1**.

Soleus neurotomy was performed in all the studies and involved 97% of patients in the series. Authors specified soleus nerve (n=390), or the upper branch of soleus (n=77) associated in 48 % of cases with lower branch of soleus (n=37). Neurotomy of tibial nerve was rarely (n=2) reported. Neurotomy of gastrocnemius was performed in 79% of studies (corresponding to 20% to 100% of studies population) [27,31–36,39,41–43,50,87–93], the presence of a clonus after soleus neurotomy being an indication to perform this surgery in 1 studies [39]. TP neurotomy was performed in 88% of studies, concerning 14% to 100% of studies population [27,31,33–39,41–43,50,78,87–91,93,94]. A neurotomy of FDL and FHL was performed in 50% [33,35,39,41–43,78,87,89–91,94] and 54% [33,35,37–39,43,50,78,87,88,91,93,94] of studies, corresponding to 46% and 61% of subjects, respectively. Four studies report additional surgeries: 3 described gastrocnemius aponeurotomy or triceps sural lengthening due to ankle dorsiflexion limitation (< 0°) [38–40], one reported lengthening surgeries of TP, FDL or FHL but also Bardot intervention for 44% of patients [27], and one reported in more than 50% of the soleus neurotomy procedures, a FDL lengthening combined with a CT lengthening or a gastrocnemius aponeurosis [38].

Table 2 summarizes clinical and instrumental criteria and **Supplemental Table S1** details all the criteria concerning neurotomy surgeries.

Passive range of motion was collected in 87% of the studies: there was no ankle dorsiflexion limitation in 13 studies and conversely a limitation was noted in 8 studies (ranging up to -35°) disappearing with knee flexion in 3 studies. Motricity (analytical testing, active range of motion, muscle control) was collected in 70% of studies [33–43,50,78,88,89,92,94] and revealed an average strength at 2.2/5 and 2.3/5 (MRC scale, from 0 to 5) for ankle dorsiflexors and plantar flexors, respectively, a selective control absent or non-functional for 22% of patients, and a synkinetic or selective voluntary control of ankle dorsiflexion for 37% and 40% of patients, respectively. Active ankle dorsiflexion (-15° on average) and eversion were decreased. The presence of spasticity was reported in all studies, with an average plantar flexor spasticity of 3.1 (1 to 4) on the modified Ashworth scale and 3.1 (1 to 4) on the Tardieu scale.

An overactivity of the TS at the initial contact was reported in 2 studies [35,94], its activation in swing phase being decreased [94] or considered as physiological [35]. Among the 13 studies reporting kinematic data, 46% pointed a lack of dorsiflexion in swing phase [34,35,37,38,50,94] and 69% an equinus in stance phase [31,34,35,38,39,50,78,88,94]. Hypertonia and/or reducibility of deformations were assessed in 83% of studies, exclusively by motor nerve block in 13 studies [27,34,37–40,50,78,88,89,92–94] and if not by other chemical ways (phenolization, curarization or botulinum toxin injections) [31,32,36,41–43,87]. Chemical evaluation before neurotomy was systematic in 46% of studies [32,36–38,41,42,50,87,88,92,94], and its response (reducibility of deformation, even if partial) was a prerequisite before neurotomy in 42% of studies [34,37,41–43,50,87–89,92]. In other cases, it was done when a varus or a claw toe was present, when passive ankle mobilization was difficult or when the botulinum toxin injection was inefficient [41,42,87].

A postoperative decrease of spasticity was reported in all studies (statistically significant for 10 studies) and assessed with electrophysiological values based on H-reflex (Hmax/Mmax) in 5 studies or a decrease in the peak of abnormal EMG activity of the TS and less co-contractions during the gait. Spastic recurrence was reported in 3 studies were neurotomies were partial [27,31,78] or not performed [27]. The deformity recurrence was corrected by complemental neurotomy 2 years later or by botulinum toxin injections [31,78]. Compared to the 3rd month, an increase in spasticity was reported 2 years postoperatively, but without returning to the initial state, and without functional degradation [88]. A recurrence of deformity related to retraction phenomena and requiring orthopedic correction was reported in 7 neurotomies' studies in about 13 to 31% of the case series [27,31,32,40,41,43,91], without specific preoperative factors identified: preoperative passive ROM were variable (including 2 retracted feet), muscle ankle dorsiflexors testing (when specified) ranged between 0 and 5 in MRC scale. However, these recurrences were observed in the studies with the longest follow-up, at least 2 years for 4 of them [27,41,43,91], with an average of 3 years, whereas the average follow-up all neurotomy studies was 2 years.

Lengthening of calf muscles without anterior tendon transfer

Fifteen studies have reported 437 calcaneal tendons lengthening and/or gastrocnemius aponeurotomy without an associated anterior tendon transfer, corresponding to 15% to 100% of studies population. Type of study, population characteristics and details of isolated lengthening surgeries were detailed in **Table 3.**

The releasing of the FDL, the FDB or FHL was performed in 13 studies [30,38,44,45,47,48,54,57–60,68,95] and associated with a CT lengthening in 97% of cases. The FDL lengthening alone was reported in 1 study (n=5, 19%) when an isolated claw toe was present [47]. TP lengthening was less frequent (6 studies, its frequency being not always specified) and was performed when a hindfoot varus was present [48,54,68] or when a varus in swing phase was not attributed to the TA [48]. In one study, TP lengthening was not performed, even if varus, to avoid the risk of secondary flat foot [44].

Table 4 summarizes clinical and instrumental criteria and **Supplemental Table S2** details all the criteria concerning isolated lengthening surgeries.

Passive ROM was reported in 40% of the studies [38,46,48,49,54,68] and all except one (in this case lengthening surgery was a Vulpius aponeurotomy) [44] reported a passive limitation of ankle dorsiflexion (equinus ranging from 0° to 60°). A varus was reported in 6 studies [45,46,58–60,95], a TP lengthening being performed for all patients in 3 of these studies [45,46,95]. Motricity was assessed in 4 studies with an average Brunnstrom score of 3, corresponding to synkinetic ankle dorsiflexion with an associated knee and hip flexion [38,44,47,48]. An active ankle dorsiflexion until neutral was sometimes a preliminary requirement to perform CT lengthening without transfer [48]. Spastic hypertonia was often not specified and could contraindicate an isolated lengthening [54,58,59]. Conversely, the lengthening could be combined with a neurotomy, if spasticity was present [38]. Presurgical assessment by motor nerve block or botulinum toxin injection was almost absent. Instrumental gait analysis was carried out in 5 studies and reported a lack of ankle dorsiflexion in stance (two studies also reported a lack of heel contact) and swing phases [38,54,58–60].

Two studies reported equinus recurrence with early recurrence on spasticity in 8% of cases [49] and 20 to 30% of equinus recurrence on a spastic population after a length of follow up of 76 months [47].

Tibialis anterior transfer

Twenty-five studies reported split TA transfer (n=812) or complete TA transfer (n=76). Type of study, population characteristics and details of TA transfer surgeries were detailed in **Table 5.**

For 96% of TA transfers (when this percentage was specified), a CT lengthening or a GM aponeurotomy was done to obtain a neutral ankle dorsiflexion or a plantigrade support. CT lengthening was therefore not systematic as in 8 studies it was performed for 75 to 98% of TA

transfers [28,29,60,62,64,68,69,96]. Other associated lengthening surgeries were often performed and concerned the flexor digitorum/hallucis (longus or brevis) or the plantar fascia release in 87% of cases [28–30,38,47,48,53–64,68–70,81,96,97], the TP in 28% of cases [28,29,48,53,56,60,63,64,68–70,81,96,97] and the EHL in 13% of cases [28,53,96]. A complementary anterior transfer to reinforce the SPLATT was performed in 8 studies using either the FHL (conditioned by its activation on dynamic EMG) [29,57,69], the TP (used instead of the FHL when it was inactive and the TP has a continuous activation on dynamic EMG) [29], or the EHL also hyperactive [70]. A transfer of the FDL on the calcaneus was performed to strengthen the weakness of the TS [28,53,70,96], when it was not retracted nor spastic [96]. An associated osteoarticular (subtalar arthrodesis or a triple arthrodesis) surgery was performed in 3 cases patients [28,29] in presence of a flat foot or bone deformity.

Table 6 summarizes clinical and instrumental criteria and **Supplemental Table S3** details all the criteria concerning TA transfer surgeries.

The presence of a varus most often indicated the TA transfer in 9 studies. Motor assessment of TA was not systematic (20% of cases) and not usually done in a precise targeted way (unquantified or using the global Brunnstrom scale) [28,38,47,55,62]. For some authors, a strong TA activation in triple flexion [62] or a minimal synergistic pattern [28,47,55] was necessary. A better result was associated with a preoperatively selective TA recruitment but it was not mandatory [63]. TA activation analyzed by dynamic EMG (197 patients) was continuous or in opposite of phase for 60%, silent for 1%, premature and/or prolonged for 30% and in phase for 9% of patients. A TA activation assessed by visual gait analysis was noted in 5 studies, specifically in swing phase [38,47,55,61] or not [97]. TP overactivity has been reported as a contraindication to split TA transfer [61]. An associated TP lengthening was reported when it showed a premature or prolonged activation [53], an activation out of phase [56] or an abnormal activation pattern [70], or in case of severe rear-foot varus in swing phase [48], or when the correction was insufficient with the CT lengthening [29]. A kinematic assessment was reported in 48% of the studies [28,38,48,53,54,56,58–61,63,96]. A dynamic varus was reported in 4 studies [29,56,61,63] and a lack of ankle dorsiflexion in swing phase or at initial contact in 8 studies [38,54,56,58–61,63], these anomalies being not related to spasticity of calf muscles (exclusion criterion) for 4 of them [54,58,59,61]. The muscle hypertonia assessment (often without the detail of the muscles involved) was mentioned in 60% of the studies [28,38,47,48,53–59,61,68,70,96], only 3 using a validate scale [38,47,55]. Presurgical nerve blocks were anecdotal [38,48,56].

Kinematic instrumental values during gait were reported in 7 studies, and showed a significant improvement of ankle dorsiflexion beyond the neutral position in swing phase [58,59,61]. Three studies reported a drop foot recurrence favored by the weakness of the transferred TA (33%) [55] which played a role mainly by tenodesis effect (9%) (better results being found when TA actively contracted) [63] or by the hypertonia of the TS (26%) [62]. Recurrences or persistence of a varus were reported in 6 studies [28–30,55,62,64], and were not attributed to TA [55] but linked to a loss of tension or weakness of the transfer [30] as well as a residual hypertonia or retraction of the antagonist muscles [28,29,65,66]. They were treated by a TP lengthening [64] or a triple arthrodesis [29].

Anterior tendon transfer, with the exception of tibialis anterior

Thirteen studies (637 patients) reported anterior transfer involving muscles other than TA. Type of study, population characteristics and details of these surgeries were detailed in **Table 5** (second part).

An anterior transfer concerning the FDL or the FHL was done in 8 studies (249 patients, corresponding to 7% to 100% of studies population [47,54,55,58–60,65,67], the EHL in 5 studies (102 patients, corresponding to 4% to 48% of studies population) [54,58–61], the TP (complete or split) in 4 studies (28 patients, corresponding to 4% to 100% of studies population) [47,73,74,98] and a retrograde transfer of the fibular longus (Bardot intervention) in 1 study (41 patients) [66]. Arguments for the choice of an alternative transfer to the TA was the prevention of a drop foot due to paresis or default of activation of the TA [55,61,73], the correction of varus and claw toe at the same time using the FDL transfer [47], or the desire to revive eversion or dorsiflexion, whether the TA is paretic or not [65,66]. A CT lengthening (when specified) was associated in 99% of the cases. A tenotomy of flexor digitorum muscles was not systematic, performed in 52% of transfers [54,55,58–61,65,66,73,74,98], and more rarely a TP lengthening was achieved in presence of a severe varus [54,55,58,60,65].

Table 6 (second part) summarizes clinical and instrumental criteria and **Supplemental Table S4** details all the criteria concerning these transfer surgeries.

Indications and clinical elements prior to the transfer surgeries were heterogeneous. EHL transfers were performed in presence of a forefoot varus, or arguments in favor of an overactivity of this muscle (hallux erectus and/or overactivity on dynamic EMG without overactivity of TA) [60,61]. For FHL/FDL transfers, a static or dynamic claw toes, or an EMG activity was a prerequisite [67]. Other studies [47,65] were based on the prior description of

FDL overactivity in swing phase [57]. In 2 studies [47,55], motricity of calf muscles was estimated above 2 on Brunnstrom scale and this weakness contraindicated the transfer. The TP transfer was considered as an alternative to TA transfer when the TA contraction was too weak [73,74], fibular muscles activation was absent during gait [73], a TP contraction was present in stance phase or its strength was above 4 on MRC scale [47,74,98], and when the varus was not attributed to the TA [73,74]. Bardot intervention was performed when TA activation in triple flexion was assessed above 4/5 in MRC scale without fibular muscles activity [66], and occasionally, this intervention was done after split TA transfer failures [28,29,64]. Gait analysis (kinematic or visual) reported a lack of ankle dorsiflexion in 7 studies [54,58–61,66,98] and a varus during the swing phase in 4 studies [54,60,61,98]. Spastic hypertonia was poorly measured and not detailed. In addition, presurgical assessment by nerve block was not mentioned. Only two studies combined tendon transfer with a neurotomy of calf muscles: a TP transfer and a Bardot technique were done with a gastrocnemius and upper nerve of soleus neurotomy in 85% [74] and 44% [27] of cases, respectively.

The transfer of other muscles in replacement or in addition to the TA intended to avoid and/or compensate the paresis of TA or to optimize the function of other hypertonic muscles (e.g. the FDL when active in swing phase) [67] or to correct a deformation at the same time (e.g. a claw toes due to a flexor digitorum hypertonia) [47]. The FDL transfer was described as effective without recurrence of drop foot [67]. Nearly 98% of the tendon transfers (other than TA) were associated with a lengthening of calf muscles, and recurrence of passive equinus was rarely reported [53,62,64] and was attributed to calf spasticity.

Osteoarticular surgeries

Osteoarticular procedures are very poorly represented in EVF surgeries and were not the main topic of studies carried out, except a case serie of talonavicular arthrodesis in chronic stroke patient with an EVF responsible for instability in stance phase [26]. The arthrodeses were described in 6 studies [27–32] as an associated surgery for 1 to 2 patients, and generally concerned talo-calcaneal, talo-navicular and calcaneo-cuboid joints. Arthrodeses were performed a few years after failure of a neurotomy or a tendon transfer [29,31,32] or initially in addition to a tendon surgery or neurotomy [27,28,30]. The objective was to obtain a plantigrade position and to stabilize the hindfoot [32]. A flat foot in stance phase could indicates arthrodeses [28].

Figure S1. Search strategy in PubMed

#1	("Stroke"[MH] OR adult[MH] OR stroke[TIAB] OR "Brain Injuries"[MH] OR "Brain Injuries"[TIAB] OR "Cerebrovascular Disorders"[MH] OR hemiplegia[TIAB] OR "Motor Neuron Disease"[MH] OR "Central Nervous System Diseases"[MH])
#2	(equinovarus[TIAB] OR "spastic foot"[TIAB] OR "foot deformities, acquired"[MH] OR "equinus foot"[TIAB] OR "Equinus Deformity"[MH])
#3	("Contracture/surgery"[MH] OR "tendon transfer"[MH] OR "tendon transfer"[Title/Abstract] OR tenotomy[TIAB] OR "tendon lengthening"[TIAB] OR arthrodesis[TIAB] OR tenodesis[TIAB] OR neurotomy[TIAB] OR "Surgical Procedures, Operative"[MH] OR "Orthopedic Procedures"[MH] OR surgery[TIAB] OR "surgical correction" [TIAB] OR neurosurgical*[TIAB] OR (tibia*[TIAB] AND anterior[TIAB] AND tendon[TIAB]) OR achille*[TIAB] OR calcaneal[TIAB] OR (tibia*[TIAB] AND posterior[TIAB] AND tendon[TIAB]))
#4	("hallux rigidus"[TI] OR Idiopathic[TI] OR congenital[TI] OR talipes[TI] OR "bone diseases"[TI] OR hip[TI] OR diabetic[TI] OR "Cerebral Palsy"[TI] OR "Rheumatic Diseases"[TI] OR rheumatoid[TI] OR leprosy[MH] OR pregnancy OR charcot[TIAB] OR arteria*[TI] OR dipleg*[TI] OR poliomyelit*[TI] OR polyneuropathy*[TI] OR amputation*[TI] OR osteotom*[TI] OR Flatfoot/surgery[TI])
Search: #1 AND #2 AND #3 NOT #4	

Table S1. Detailed content of articles concerning neurotomies of calf muscles.

Authors **Date** **Type** **MINORS score**	**Surgery** (number; % of total), degree of section **Additional surgery**	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range]	**RESULTS**		
								PROM [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD)	**Autonomy/comfort** **Complications** (recurrence, dysesthesia, weakness) **Kinetic data** **Kinematic data**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Bollens *et al.* 2013 RCT 20/24	SOL (8; 100%; *66%)* TP (5; 63%; *50%)* FHL (5; 63%; *100%)* – No	Stroke (8) 49.8 [32-70] 30 [8.4-82.8]	ADF-KE = -7.5 [-15/2.5] ADF-KF =2.5 [-5/12.5] Authors' opinion: "Contracture is a contraindication so ADF>0 needed" - *MRC* TS= 2 [1/3.5] TA= 3 [0.5/4]	MAS TS-KE= 3 [2.5-3] TS-KF= 3 [2.5-3] TAR TS-KF= 4 [3-4] - NS	Instrumental gait analysis ADF-IC = -8.4 (6.4) ADF-StP = 6.9 (10.6) ADF-SwP=-6.6 (6.8) Ability to walk on a treadmill	↑ foot positioning during gait needed after nerve motor block (SOL and TP if insufficient)	6 m	ADF-KE= 0 [-12.5/2.5] ADF-KF=10 [7.5/10] - MRC TS= 2 [1/3] TA= 3 [0.5/ 4.5]	MAS TS-KE= 2 [1.5/2] * TS-KF= 0 [0/1] * TAR TS-KF= 0 [0/1] * ↓ L path *	No ≠ in FAC, participation, quality of life Sensitive disorders= 12% No ≠ in kinetics ADF-IC = -4.1 (4.3) ADF-StP = 10.6 (9.7) * ADF-SwP =-2.6 (7.1) *
Buffenoir *et al.* 2004 P, CS 9/16	SOL (55; 100%; *NS*) GM (NS but surgeon advice) TP (39; 71%; *50-100%* if varus) FDL (36; 65%; *10-100%;* if claw toes) FHL (28; 51%; *50-100%*) – No	Stroke (34) TBI (8) Others (13) 43.5 [12-74] 64 [3-320]	Equinus (n=53) Varus (n=39) Claw toes (n=33) ADF-KF= 3.5 ADF-KE= -0.6 - *ADF activation:* Absent (n=6) Synkinetic (n=17) Weak (n=15) Present (n=17) ADF by TA exclusively (n=11) ADF with TA and FDL activation (n=10) ADF with TA, FDL, peroneus activation (n=11)	TAR TS-KE= 2.5 TS-KF=2.4 TP= 1.3 FDL= 0.9 Clonus: TS-KE& KF (n=45) TP (n=19) FDL (n=8) - NS	Recurvatum n=30 Orthosis 23 OS 11	NS	10 m [4-22]	↓ equinus, varus and claw toes score * ADF-KF= 8.7 * ADF-KE= 6.8 * - No ≠ in strength of ADF (qualitative or quantitative)	TAR TS-KE= 0.5 * TS-KF= 0.3 * TP= 0.2 * FDL= 0.5 * ↕ clonus	↕ orthosis 11/23 Severe ADF deficit for 1 (present in preoperative) ↑ mean walking distance and time, and speed * ↓recurvatum *

Authors **Date** **Type** **MINORS score**	**Surgery** (number; % of total), degree of section **Additional surgery**	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range]	**RESULTS**		
								PROM [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD)	**Autonomy/comfort** **Complications** (recurrence, dysesthesia, weakness) **Kinetic data** **Kinematic data**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Rousseaux *et al.* 2009 P, CS 12/16	SOL (51; 100%; *60-80%*) GM (50; 98%; *60-80%*) TP if varus (27; 53%; *NS*) FDL if claw toes (10; 20%; *NS*) – No additional surgery	Stroke (51) 51 (12) 44 [11-304]	ADF-KE=2 (9) APF=54 (8) INV=26 (6) EV=6 (4) No contracture – MRC: ADF=1.5 (0.8) APF=2.8 (0.9) AROM: ADF-KE=-19 (11) APF=43 (9) INV=10 (8) EV=-4.7 (8)	MAS TS=2.8 (0.9) Clonus for 21 – NS	In orthostatic position: APF=8 (10) Varus=6 (11) Heel-ground (cm)=0.7 (1.6) – Orthoses (n=27) OS (n=10)	BTI before STN (100%) NB of TN if BTI inefficiency to exclude contracture (n=16; 31%) Neurotomy if spastic component limit function, and function increase after BTI or NB	2 y	ADF-KE=12 (8) * No difference in INV, EV and APF – MRC: ADF= 2 (1)* APF= 2.4 (1)* AROM: ADF-KE=-6 (12) * APF=39 (11)* INV=6 (8)* EV=-0.2 (6) *	MAS: TS= 0.9 (0.9) * (but increase compare to M3) Stop clonus	Stop orthoses = 15/27 Stop OS = 2/10 Stop cane = 6/36 FAC barefoot increase from 2.7 (1.5) to 3.3 (1.1) * (no difference with shoes) Plantar sole flattening after STN of TP in 11/27 (40%) cases Discrete increase of spasticity at 1 y Calf contracture (because not responding to lidocain block) in 8 cases Sensitive disorders in 18/51 cases No ≠ in spatio-temporal parameters Distal gait pattern: initial contact was more frequently plantar foot or by the heel Decrease recurvatum in stance phase In orthostatic position, decrease of: APF=0.9 (4.8) *; Varus=0.7 (3) *; Heel-ground (cm)=0*
Decq *et al.* 2000 P, CS 12/16	UNS (46; 100%) LNS (21; 46%) GM (9; 20%) if clonus persists after STN-SOL TP (18; 39%) if varus FHL (16; 35%) **&**FDL (17; 37%) if claw toes – GM-apo (4; 9%) if ADF<0	Stroke (18) TBI (15) Others (13) 36 [8-79] 96	ADF-KE= [-10/0] (n=4) ADF-KE > 0 (n=36) – *ADF activation:* Voluntary ADF with TA or EDL (n=28) Synkinetic ADF with TA or EDL (n=7) ADF absent (n=11)	MAS TS-KE **&** KF = 2 TAR APF = 4 – NS	Video assessment Recurvatum=14 ADF-StP = -3.8 – Orthoses 14	SOL	15 m [8-28]	NS – NS	MAS TS-KE **&**KF = 0 TAR TS-KF= 0 for all TS-KE= 3 for 2 and 0 for the other	↕ orthosis :4/14 No No ≠ in spatio-temporal parameters ↕ recurvatum: 8/14 (57%) ADF-StP= 4.2 *

Authors **Date** **Type** **MINORS score**	**Surgery** (number; % of total), degree of section **Additional surgery**	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range]	**RESULTS**		
								PROM [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD)	**Autonomy/comfort** **Complications** (recurrence, dysesthesia, weakness) **Kinetic data** **Kinematic data**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Rousseaux *et al.* 2008 P, CS 12/16	GM & SOL (34; 100%; *60-80%*) TP (27; 79%; *NS*) FDL (10; 29%; *NS*) – No	Stroke (34) 50.4 (11.5) 45 [7-293]	ADF= 1.5 APF= 53.8 INV= 24.7 EV= 5.9 - MRC: ADF= 1.6 APF= 2.8 AROM: ADF= -18.6 APF= 43.5 INV= 11.2 EV= -6.1	MAS APF= 2.9 Clonus APF=0.4/2 (0 absent, 1 fatigable, 2 non fatigable) - NS	NS - Orthoses 19 OS 7	BTI on calf muscles, 6-12 months before STN (n=34, 100%) TN if BTI inefficient to exclude contracture (n=5; 15%)	1 y	ADF= 12 * APF= 52 INV= 26 EV= 7.8 * - MRC: ADF= 2 * APF= 2.4 AROM: ADF= -4 * APF= 37.4 * Inv= 6.8 * Ev= -0.5 *	MAS: APF=0.7 * APF clonus=0 *	↕ orthosis 13/19 ↑ FAC barefoot * Plantar sole flattening or valgus= 11 (32%) Discrete sensitive disorders (35%) (due to STN TP/FDL) ↑ Rivermead Motor Assessment and distal gait pattern * ↑ gait comfortable speed *
Deltombe *et al.* 2015 P, CS 12/16	SOL (30; 100%; *75%*) GM (16; 53%; *75%*) TP (26; 87% ; *70%*) FHL (22; 73%; *100%*) – No	Stroke (25) TBI (5) 45 [20-69] 48 [15-218]	ADF-KF= 5 [0/10] ADF-KE = 0 [-10/5] - *MRC:* TS=3 [2-4] TA=4 [3-4]	ASH TS= 3 [3-4] TP= 1 [0-2] - NS	Video assessment during barefoot walking: ADF-StP= -5 [-15/5] ADF-SwP= -20 [-15/-25] Varus-StP= 10 [0/20] Varus-SwP= 20 [15/25] - NS	TN (n=2; 7%) UNS (n=28; 93%) GM (n=2; 7%) TP (n=25; 83%) After block: ADF-KE>0, and ↓equinus and varus	2 y	ADF-KF= 10 [10-15] ADF-KE= 5 [-5; 10] ADF ↑ at 2m & returned at the baseline at 2y - MRC: TS= 3 [2-4] (↓ at 2m & returned at the baseline at 2y) TA= 4 [4-4]	ASH TS= 1 [0-1] * TP= 0 [0-0] *	NS No sensitive disorder At 2 y: ↑ gait speed * ADF-StP= -5 [-10/10] * ADF-SwP=15 [10/20] * Varus-StP= 0 [-5/5] * Varus-SwP=15 [10/20] *
Le Bocq *et al.* 2016 P, CS 8/16	SOL (23; 100%) GML and GMM (23; 100%) TP (10; 43%) *(60 to 80% section)* – No	Stroke (23) 57 [48-63] 28 [9-133]	ADF-KF= 5 [0/10] ADF-KE= -5 [-10/0] - *MRC:* TS=2 [2-3] TA=1 [1- 2]	MAS TS= 4 [3-4] TP= 2 [1-3] - NS	Varus in StP & SwP Equinus in StP & SwP - Orthoses 15 OS 3	Clinical improvement needed after TN block	5 m	ADF-KF= 15 [12-20] * ADF-KE= 10 [5-15] * - TS = 2 [1-2] TA= 2 [1-3] *	MAS TS= 0 [0-1] * TP= 1 [0-1] *	↕ orthosis for 3 ↕ OS LL-FAS ↑ (functional score) * Sensitive disorder: 3/23 (2/3 had STN TP) ↑ maximum speed *

Authors **Date** **Type** **MINORS score**	**Surgery** (number; % of total), degree of section **Additional surgery**	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range]	**RESULTS**		
								PROM [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD)	**Autonomy/comfort** **Complications** (recurrence, dysesthesia, weakness) **Kinetic data** **Kinematic data**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
										↓ varus &equinus in StP * ↓ varus in SwP * No ≠ for equinus in SwP
Deltombe *et al.* 2018 P, CS 11/16	SOL (12; 67%) TP (7; 39%) FHL (11; 61%) – GM-apo (6/12; 50%) CT-l (2/12; 16%) FDL-l (7/12; 58%) STN if spasticity Lengthening if retraction	Stroke (18) 56 (10) > 6	ADF= -9 (12) - MRC TA= 0.5 [0-3] TS= 0.5 [0-3] AROM ADF= -19 (13)	TAR TS-KE= 2.5 [1-4] TS-KF= 3 [1-3.8] MAS: TS-KE= 3 [2-4] TS-KF= 2.5 [2-3]	Video assessment (double blinded assessor) ADF-SwP= -26 (10) ADF-StP= -16 (10) - Walk 10 m Orthoses 5	TN branch for all	1 y	↑ PROM: ADF= 14 (16) * - No ≠ in MRC or in AROM ADF= -6 (21)	↓ of TS (KE & KF) spasticity *	↕ orthosis for 5 No REC ↑ Speed barefoot (after 3 months) * (no ≠ with aids) ADF-SwP= 9 (10) * ADF-StP= 7 (17) * No ≠ in activities (FAC) or participation
Buffenoir *et al.* 2013 P, CS 12/16	UNS (15; 100%; *67-80%*) LNS (10; 67%; *50-100%*) GML (3; 20%; *50-67%*) GMM (0) TP (9; 60%; *100%;* if varus) FDL/FHL (7; 47%; *100%;* if claw toes) – No	Stroke (9) TBI (4) Others (2) 47 [22-66] 86 [12-424]	Equinus n=15 Varus n=9 Claw toes n=7 ADF-KE in orthostatic position =9.2 (4.8) - NS	TAR TS-KE =2.7 (0.5) TS-KF=2.3 (0.8) MAS TS-KE=2.3 (0.7) TS-KF=2 (0.6) H_{max}/M_{max} SOL ↑ - NS	No initial heel contact for all IC = Toe for 5 Forefoot 6 Plantargrade for 4 (visual via physician rating scale) - walking with cane for 9, without help for 6	BTX before STN (n=7; 47%) with insufficient effect Tibial nerve block (n=15; 100%)	15 m	↕ equinus-varus-claw toes in orthostatic position ADF-KE =18.2 (1.7) * - NS	↓of passive stiffness TAR: TS-KE= 0.1 (0.4) * TS-KF= 0.1 (0.3) * MAS: TS-KE= 0.1 (0.3) * TS-KF= 0 (0) * ↓ Mmax for SOL at early assessment return to preSTN value ↓ H_{max}/M_{max} for SOL at early assessment and late assessment (↓ 78%) no ≠ for GML/GMM for M_{max} & H_{max}/M_{max}	Independent Walking score (functional) ↑ * Walking with cane for 3. without help for 12 No IC = heel for 11 plantargrade for 4 ↑ physician rating scale (visual gait analysis) *

Authors **Date** **Type** **MINORS score**	**Surgery** (number; % of total), degree of section **Additional surgery**	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range]	**RESULTS**		
								PROM [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD)	**Autonomy/comfort** **Complications** (recurrence, dysesthesia, weakness) **Kinetic data** **Kinematic data**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Deltombe *et al.* 2008 P, CS 9/16	SOL (11; 100%) TP (10; 91%) GM (9; 82%) FHL (8; 73%) *(60 to 90% section)* – No	Stroke (10) TBI (1) 51 [38-57] NS	ADF =10.4 (6.9) Varus – *MRC* TS=3.3 (1.1)	ASH TS=3.3 (0.9) NS	Video assessment during barefoot walking: ADF-StP= - 6.8 (12.3) Varus-StP=15 (16.3) Varus-SwP= 19.6 (6.5) – NS	SOL (n=11;100%) TP, GM and FDL if needed Clinical improvement needed (↓ spasticity & ↑ function)	1 y	ADF= 15 (5) * – MRC TS= 2.3 (0.9) * (reincrease compare to evaluation at 2 months)	ASH TS=0.4 (0.5) * Clonus TS ↕ ↓Hmax, Mmax and Hmax/Mmax for SOL* ↓ MUNE * Reincreased Mmax comparative to 2 months evaluation	NS NS No ≠ in spatio-temporal parameters ADF-StP= 0 (9.7) * Varus-StP= 2.3 (9.8) * Varus-SwP= 13.2 (8.7) * No ≠ for recurvatum
Buffenoir *et al.* 2008 P, CS 7/16	UNS (7; 100%; *50-80%*) LNS (5; 71%; *50-100%*) TP (7; 100%; *50-100%*) FHL (6; 86%; *80-100%*) FDL (5; 71%; *80-100%*) GM (0) – No	Stroke (4) TBI (2) Other (1) 41 [19-71] 37 [10-45]	Equinus (100%) Varus (86%) Claw toes (71%) ADF-KE= 7 [0-10] ADF-KF= 10 [0-15] – *ADF activation:* Inactive (n=2) Syncinetic (n=3) Selective (n=2)	TAR TS-KF =2.6 (n=7) TS-KE =2.4 (n=7) TP=0.9 (n=6) FDL=0.9 (n=4) TS abnormal activation at beginning StP TA activity ↓ in beginning StP TS and TA normal activation in SwP	Video assessment ADF-IC= -29 (3.5) ADF-StP= -16 (4) ADF-SwP= -28 (4) Recurvatum (n=3) Orthoses 5	GMM and GML then UNS (1-week interval) for all	1 m	↓ equinus, varus and claw toes * ADF-KE=16 * ADF-KF= 12 * TS, TA and peroneal were not quantitatively or qualitatively modified at EMG	TAR TS-KE =0.71 * TS-KF=0.48 *	↕ orthosis for 2 ↑ speed gait and distance * ↓ bipedal StP * ADF- IC= -20 (3.7) * ADF-StP= -0.5 (2) * ADF-SwP= -13 (4) * No strike by heel (because of lifter deficit)
Abdennebi & Bougatene 1996 R, CS	SOL (66; 100%) GM (66; 100%) TP (29; 44%) FDL (10;15%) *(33 to 66% section)* –	Stroke (6) TBI (4) Others (48) 66 feet 24 [5-65]	Not retracted (no fixed deformity) – *ADF activation:* Absent(n=15) Non-functional	ASH APF= 3.2 [2-4] Ankle clonus (n=16) Spastic deformity:	NS – NS	TN if doubt about fixed deformity	4,2 y	NS – Voluntary motor activity of the antagonist ↑ for 66%	↓ spasticity in 80%	Better standing with good plantar pressure on ground (65%) Sloping foot (talus): 2 (weakness of TS) REC: 4

Authors **Date** **Type** **MINORS score**	**Surgery** (number; % of total), degree of section **Additional surgery**	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range]	**RESULTS** **PROM** [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD)	**Autonomy/comfort** **Complications** (recurrence, dysesthesia, weakness) **Kinetic data** **Kinematic data**
							Statistically different* (if not mentioned, no statistical difference or not assessed)			
4/16	No	> 12	(n=21) Functional(n=22)	Equinus (n=66) Varus (n=29) Claw toe (n=10) NS						NS
Sindou *et al.* 1988 R, CS 5/16	SOL & GM (58; 94%) TP (45; 72%) FHL/FDL (38; 61%) *(50 to 80% section)* No	Stroke (19) TBI (14) Others (20) 62 feet 36 [6-68] 48 [24-204]	ADF (0 to 20) >20 (n=18) [10-20] (n=12) [0-10] (n=15) 0 (n=8) Varus 45 Equinus 54 Claw toes 38 *MRC* ADF= 2.5 [0-5] APF= 0.8 [0-4]	ASH APF= 3.8 [3-5] Clonus (n=27) NS	NS All walk with orthosis or OS	When passive mobilization impossible => curarization test for 5 or TN motor block for 11 (beside differentiate TA varus contribution)	3 y [15 m-10 y]	ADF >20 (n=41) [10-20] (n=2) [0-10] (n=8) 0 (n=2) ↕Equinus 85% ↕Varus 89% ↕Claw toes 74% MRC ADF=3.3 [0-5] (when MRC= 0 initially, no improvement) Voluntary motricity ↑ in 87% APF= 3.3 [0-4]	ASH: APF= 1.5 [1-3] for 92% ↕ clonus 67%	↕ orthosis or OS in 82% Sensitive disorder (transient 60%, permanent 40%) when FDL STN (9%) Claw toes REC: 3 Equinovarus REC: 8 Spasticity REC: 0 NS
Sindou *et al.* 1985 R, CS 2/16	SOL/GM/TP/FDL (NS; *80%*)	BI (25) Others (14) 47 feet 35 [6-68] NS	NS NS	Spasticity NS	NS	NS	4 y [1-9]	NS Voluntary motricity: ↑for 38, no change for 8 and ↓ for 1	↕ spasticity 42 and ↓ for 5 89% good results	NS Permanent sensitive disorder =2
Palacio *et al.* 2010 R, CS	SOL (23; 92%; *50-100%*) GM (24; 96%; *50-*	Stroke (18) TBI (7)	NS NS	Clonus (n=25;100%) ASH	NS Orthoses 6 OS 16	TN (n=19;76%) Partial or complete	11 y [4-19]	NS NS	ASH TS= 0 or 1 for 22 n ↕ Clonus for 14 and	Orthoses 3 OS 8 Technical aids 17 Walking barefoot possible for 11 (61%)

Authors **Date** **Type** **MINORS score**	**Surgery** (number; % of total), degree of section **Additional surgery**	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range]	**RESULTS**		
								PROM [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD)	**Autonomy/comfort** **Complications** (recurrence, dysesthesia, weakness) **Kinetic data** **Kinematic data**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
7/16	*100%*) TP (1; 4%; *NS*) – TP-l (8/25) Bardot (11/25) FDL-l (7/25) FHL-l (6/25) Tenodesis LEH & TA (Haglund's procedure) (1/25) Talonavicular arthrodesis (1/25)	Age of accident: 38 [3-68] 62 [6-444]		TS ≥ 3 for all - NS	Technical aids 22 Walking barefoot impossible for 18 FAC=5.12	clinical improvement			persist for 8 Tonic and/or clonic spasticity in SOL persisted (12%) (if STN SOL had partial resection (50%) or not performed)	↑ Walking distance for 20 (80%) ↑ FAC= 5.8 * Sensitive disorders (1, 4%) 8 reinterventions: - 4 because of retraction (TC-l for 3, GM-apo+ Bardot for 1) - 1 because of early reinnervation - 3 claw toes (=>FDB-r ± FHB-r) No Talus NS
Kim *et al.* 2010 R, CS 5/16	Branch of posterior tibial nerve (NS; *50-70%)* – No	Stroke (5) TBI (7) 13 feet 31 [17-51] > 12	ADF= 11.2 (1) Equinus: 13 Varus: 9 Claw toes: 6 - NS	ASH TS= 3.6 (0.4) Clonus score= 1.6 (n=7) (0 absent, 1 fatigable, 2 non fatigable) - NS	NS - NS	NS	36 m [12-56]	ADF= 17.6 (1.8) - NS	ASH TS= 1.6 (0.7) ↓ APF clonus score= 0.3	NS ↑ satisfaction 25% of patients need complementary orthopedic correction 4 retracted feet NS
Fève *et al.* 1997 R, CS 5/16	SOL & GM (12; 100%) – No	Stroke (6) TBI (5) other (1) 35.8 (15) 52.7 (22)	ADF= 6 [0-20] - *ADF activation:* Syncinetic (n=3); Voluntary control (n=9) *AROM* ADF= -4 [-10/10] *MRC* TS = 4 to 5	TAR TS=3.5 [2-4] - NS	Plantigrade support possible - Orthoses 8	TN (n=12; 100%), to test reducibility of the equinus	1 m	No ≠ in PROM - No ≠ when syncinetic. AROM of ADF ↑ for 66% of patients* ADF=0 (n=7) ADF=5 (n=2) ADF=10 (n=4) MRC TS = 2 to 3	TAR TS= 0 for 11 and 2 for 1 ↓ Hmax, Mmax and Hmax/ Mmax for SOL * no ≠ for GML and GMM	Orthoses (n=2) (when no voluntary ADF before surgery) No≠ for speed gait

Authors **Date** **Type** **MINORS score**	**Surgery** (number; % of total), degree of section **Additional surgery**	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range]	**RESULTS**		
								PROM [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD)	**Autonomy/comfort** **Complications** (recurrence, dysesthesia, weakness) **Kinetic data** **Kinematic data**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Caillet *et al.* 1998 R, CS 7/16	SOL & GML/GMM if equinus and/or ankle clonus TP if varus FDL & FHL if claw toes (NS; *about 60% section)* – No	Stroke (9) [25-69] > 12	ADF-KE= - 15 [-25/0] Varus = 6 [0/10] – Motricity allowing a barefoot walking *ADF activation:* Selective (n=2) Syncinetic (n=7)	MAS TS= 3.4 [3-4] 8 patients tested **<u>TA</u>**: At StP: Normal = 6 Continuous= 2 At SwP: normal for all **<u>TS</u>**: At StP: Abnormal = 8 (peak at beginning for 6) At SwP: activity at the end for 6	Instrumental gait analysis For 6 Equinus in SwP and ADF-StP (<20) ↓ For 2: ADF at StP & SwP=0 – Orthosis 4 Barefoot walking is possible Winter groups (for 7 patients): G1 (n=2) G2 (n=1) G3 (n=1) G4 (n=3)	NS	6 m	ADF-KE= -2* ADF-KF =5 ↕ varus (neutral position) – Selective motricity no ≠ except for 1 patient (syncinetic became selective)	ASH TS 0 ↕ peak activity of TS at the beginning of StP for the 6 patients and at the end of SwP for 4/6 patients (other muscle NM)	put shoes easier ↕ ankle pain ↕ cutaneous lesion Sensitive disorders: 3 (if STN of FDL) Valgus and Hyperpression on intern side of the foot :1 (no TA activity, activity of peroneus muscles present and ↓ varus forces consecutive to STN) No ≠ in spatio-temporal parameters ↓ Equinus in SwP for 4 and in StP for 5 ↕ recurvatum in StP for 5/6 ↑ on winters scale when between I to III group. No ≠ for patients in group IV: more severe Winter groups (for 7 patients): Normal (n=1) G1 (n=2) G2 (n=1) G3 (n=0) G4 (n=3)
Roujeau *et al.* 2003 R, CS 10/16	UNS (7; 100%; *60-80%)* FDL/FHL (2; 29%; *66-80%)* TP (1; 14%; *66%)* – No	Stroke (1) TBI (2) Others (3) 7 feet 28 (13) 67 [8-144]	ADF-KE= [0-5] – *ADF activation:* Synkinetic ADF with TA and EDL (n= 2) No motor control (n= 4)	TAR TS-KE = 3.5 [2-4] TS-KF = 3.8 [3-4] – NS	severe equinus, no heel strike recurvatum 3 – NS	TN when varus or claw toe (50%) If positive block, STN of TP if varus, STN of FDL/ FHL if claw toe, STN TP+FDL+FHL if varus + claw toe	29 m [10-48]	ADF-KE: no ≠ for 5, ↑ for 2 [5-15] – Syncinetic ADF for 4 (3 acquired) Voluntary control but weak for 1 (acquired)	TAR TS-KF= 0 for 6 and REC for 1 TS-KE= 0 for 4 and REC for 3 Clonus TS-KF ↕ for 6 and REC for 1 ↓ H_{max}/M_{max} & remained at 2 y* ↓ M_{max} initially & ↑ at 8m	NS Varus/Equinus/Claw toes REC= 1 (STN GM/FDL/FHL at 26 m) Claw toes/ Equinus REC and H/M reincreased =1 (STN SOL/FDL at 24 m) Recurvatum ↓ for 1/3 and ↕ for 2/3 Contact heel- ground possible for all. 2nd rocker restored for only 1

Authors **Date** **Type** **MINORS score**	**Surgery** (number; % of total), degree of section **Additional surgery**	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range]	**RESULTS**		
								PROM [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD)	**Autonomy/comfort** **Complications** (recurrence, dysesthesia, weakness) **Kinetic data** **Kinematic data**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Collado *et al.* 2006 R, CS 4/16	TN (2; 50%; *NS*) SOL (2; 50%; *80%*) With STN SOL; GM (1) or TP (1) – No	Stroke (2) TBI (2) 35 [6-62] >12 m	ADF-KE= -20 [-10 to -35] ADF-KF= -10 [-5 to -15] Varus (n=1) - NS	ASH SOL= 3.7 [3-4] GM= 2 [1-4] Clonus (n=2) - NS	No heel contact for 1 forefoot IC for 1 - Orthosis 1 technical aid for all	TN (n=2) BTX shows good results (n=1)	48 m [14m-11y]	Initial improvement and return to pre-operative state at the late follow up and even worse - NS	Initially↓ then recurrence	orthosis and technical aids continued REC for all: Treated for 3 by BTI at 7 m, 19 m & 29 m). For 1, supplemental surgery at 11 y (CT-l + FDB-r + triple arthrodesis) NS
Deltombe *et al.* 2006 R, CS 7/16	SOL (3; 100%; *70-90%)* GMM (3; 100%; *50-80%)* GML (3; 100%; *75-90%*) FHL (3; 100%; *80%)* TP (2; 67%; *75-80%;* if additional improvement after NB) – No	Stroke (3) 54 [45-69] 23 [15-30]	ADF KE= 5 [-5/10] - NS	ASH TS = 4 - ↑ Index of co-contraction APF/ADF	Instrumental gait analysis ADF-IC= -15 ADF-StP= 0 - Orthosis 2	TP, SOL, GM block & clinical improvement (↑gait kinematics, ↓spasticity)	2 y	ADF= 10 for the 3 cases - NS	ASH TS =1 for all ↓H_{max}/M_{max} ↓ Index of co-contraction APF/ADF	↕ orthosis REC=0 For all: ↑ ADF-IC= - 4 ↑ ADF-StP= 10 ↓ Recurvatum-StP ↑ Speed gait
Bleyenheuft *et al.* 2008 R, CS 7/16	UNS (*75%*) & UNS (*80%*) + LNS (*30%*) + GM-apo – GM-apo if retraction (1)	Stroke (2) 47 & 68 16 & 32	ADF-KE= 5 [0/10] ADF-KF= 12.5 [5/20] - *MRC* ADF= 3.5 [2/5] APF= 1.5 [1/2]	TAR APF= 4 [4/4] Clonus: 2 - NS	NS - NS	Response after motor block of the upper motor nerve= ↓ spasticity	7 m & 19 m	ADF-KE= 2.5 [0/5] ADF-KF= 12.5 [10/15] - MRC (no ≠) ADF= 3.5 [2/5] APF= 1.5 [1/2]	TAR APF=0.5 (0 &1) ↓ in elastic and viscous stiffness	NS ↓ passive ADF at 2 y for the 2nd patient NS
Bensoussan *et al.* 2010 CR	SOL GML GMM —— No	Stroke (1) 44 53	ADF-KF= -5 ADF-KE= -30	MAS GM=3 SOL= 3 SOL & FDL	Equinus, varus lateral forefoot side strike -	No but partial and short efficacy of BTX in TS	9 m	ADF-KF= 10 ADF-KE= 0 - NS	↓ spasticity during 8 m then recurrence MAS SOL=3	walk barefoot w/o help possible 3 m after but ↓ autonomy at 9 m (Tcane and orthosis) => loss of plantar contact and claw toes in StP and SwP

Authors **Date** **Type** **MINORS score**	**Surgery** (number; % of total), degree of section **Additional surgery**	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range]	**RESULTS**		
								PROM [range] or (SD), deg **Motricity**: strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD)	**Autonomy/comfort** **Complications** (recurrence, dysesthesia, weakness) **Kinetic data** **Kinematic data**
							Statistically different* (if not mentioned, no statistical difference or not assessed)			
6/16			no heel contact NS	clonus NS	T cane orthosis				GM=4 (no clonus on SOL, clonus on FDL)	REC at 9 m needing a triple arthrodesis (subtalar & transverse joint), CT-l & FDB-r 3 years after neurotomy no ≠ in walking speed
Jang *et al*. 2004 CR 4/16	SOL GM TP *(50 to 80% section)* No	TBI (1) 37 21	ADF = -30 *MRC* ADF= 2	MAS APF= 4 NS	NS Standing impossible	Phenolization 3 times of GM => spasticity and ankle clonus ↓, ADF ↑ but only for 2 months	3 y	ADF= 0 MRC ADF= 4 (at 12 m)	MAS APF= 0 ↕clonus	Able to walk & run without orthosis No NS NS

(Tibial nerve= TN)

Table S2. Detailed content of articles concerning lengthening of calf muscles without anterior transfer

Authors Date Type MINORS score	Surgery (number; % of total) Additional surgery	Pathology (total population) Age [range] or (SD), y Delay [range], m	Passive ROM [range] or (SD), deg Motricity strength in MRC scale, AROM in deg	Muscle hypertonia [range] or (SD) Dynamic muscle activation (visual or EMG)	Instrumental or visual kinematic gait analysis Autonomy	Botulinum toxin injection (BTI) or nerve block (NB)	Length of follow up [range]	RESULTS		
								Clinical examination	Autonomy /Gait	Complications/ recurrence (REC)
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Deltombe *et al.* 2018 P, CS 11/16	CT-l (4; 22%) FHL-l (3/4) FDL-l (4/4) Lengthening if retraction (performed also with STN when spasticity)	Stroke (18) 56 (11) > 6	ADF= -9 (12) *MRC* TA= 0.5 [0-3] TS= 0.5 [0-3] *AROM* *ADF*= -19 (13)	*Tardieu* TS-KE= 2.5 [1-4] TS-KF= 3 [1-3.8] *MAS* TS-KE= 3 [2-4] TS-KF= 2.5 [2-3] NS	ADF-SwP = -26 ADF-StP= -16 Walk 10 m Orthoses 5	TN branch for all	1 y	↑ PROM* ↓ of TS (KE & KF) spasticity* No ≠ in MRC or in AROM	↕ orthosis for 5 ↑ Speed barefoot (after 3 months) * (but no ≠ with aids) ↓ Equinus in SwP &StP* No ≠ in activities (FAC) or participation	No REC
Takahashi & Shrestha 2002 R, CS 4/16	GM-apo (230; 100%) FDL/FHL-l if claw toes (NS) TP preserved even if retracted or hindfoot varus to maintain stability	Stroke (230) Significant medical comorbidities 67.7 [46-8] [3-6]	ADF-KE= 1.5 (6) ADF-KF= 7.2 (4.7) (n=140 tested) BRS 1=5 BRS 2=27 BRS 3=89 BRS 4=72 BRS 5=8 BRS 6=0 (n=201 tested) => start of recovery needed to consider surgery	cf. BRS NS	NS (gait analysis often done) walking w/ (n=218) or w/o orthoses (n=12)	NS	NS	ADF-KE= 11.5 (5) ADF-KF= 16.5 (4.5) (n=140) BRS 1=0 BRS 2=7 BRS 3=66 BRS 4=105 BRS 5=22 BRS 6=1 (n=201) ↑ particularly for BRS 3 and 4 ↕ Clonus	↑ gait ↓ need of walk aids (72%) Walking w/ (n=181) or w/o orthoses (n=49)	No equinus REC Claw toe insufficiently corrected for 8
Carda *et al.* 2009 R, CS 7/16	GM-apo or CT-l (52; 29 %) TP-l if rear-foot varus (NS)	Stroke (177) 49.7 (14) 67,2 (89,5)	ADF-KE ≤ 0 w/ or w/o varus (it indicates transfer) NS	No clonic activity in the StP and/or SwP. No spastic dystonia. No requiring BTI /phenol block/	Laboratory Gait analysis ADF StP = -0.77 (9) ADF SwP = -6.1 (11)	NS	1 y	NS	↕ assistance/ aids for 18/112 (16%) ↕ Orthoses for 22/28 (78%) ↑ paretic propulsion	REC of claw toes = 3

Authors Date **Type** **MINORS score**	**Surgery (number; % of total)** **Additional surgery**	**Pathology (total population)** **Age [range] or (SD), y** **Delay [range], m**	**Passive ROM [range] or (SD), deg** **Motricity strength in MRC scale, AROM in deg**	**Muscle hypertonia [range] or (SD)** **Dynamic muscle activation (visual or EMG)**	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow up [range]**	**RESULTS**		
								Clinical examination	**Autonomy /Gait**	**Complications/ recurrence (REC)**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
	FDL-l if claw toes (NS)			STN in calf muscle (no BTI in the last 9 m) NS	Walking >10 m barefoot (study design) Walking with: assistance or aids 112 Orthosis 28				↓ plantarflexion moment peak* ↑ADF-StP = 2.4 (7) * ↑ ADF-SwP = 4.3 (10) * ↑ of kinetics parameters (propulsion) and speed * ↑ walking handicap score*	
Mooney & Goodman 1969 R, CS 1/16	CT-l (40; 32%) FDL-l (40/40) if claw toes TP-l if rear-foot varus	Stroke (122) 55 [17-84] NS	Equinus: contracture or spasticity NS	Equinus: Contracture or spasticity NS	NS Ambulatory before the procedure when CT-l was the only procedure	NS	6 m	NS	↑ambulation tolerance Stable stance foot posture	Calcaneal walking result of complete tenotomy (5%) => weak functional result
Lee & Ko 2005 R, CS 7/16	CT-l (25; 100%) No	BI (18) 25 feet 39.9 [23-64] >1 y	ADF-KE < -15 NS	Spasticity present NS	NS NS	NS	25.5 m [12-37]	NS	NS	- 2 (8%) equinus REC on spasticity - No tendon rupture - 1 incomplete correction (equinus preop of 45°)
Yamamoto *et al.* 1992 R, CS 10/16	GM-apo alone (5; 6%) FD-r alone (5/75; 6 %, if claw toes) GM-apo + FD-r (16/75; 21%)	Stroke (75) 57 18	Equinus w/o varus (if varus, it indicates transfer) BRS 3 to 5 <u>GM-apo/ FDL-r /</u> <u>GM-apo + FDL-r:</u> BRS 2=0/0/0 BRS 3=2/0/3 BRS 4= 1/2/10 BRS 5=2/2/3 BRS 6=0/1/0	cf BRS NS	NS Orthosis 26	NS	6.4 y (20/26 reassessed)	NS	- ↑ speed - ↓ need of walking aids (6 used orthoses sometimes, no orthoses for 20) - 65% patients satisfied 77% could leave home - Autonomy not related to operative technique but to age, degree of paralysis and speed gait at discharge	REC: 3 (60%) equinus after FD-r 1 (20%) equinus or equinovarus after GM-apo 5 (31%) equinus or equinovarus after GM-apo +FD-r

Authors **Date** **Type** **MINORS score**	**Surgery (number; % of total)** **Additional surgery**	**Pathology (total population)** **Age [range] or (SD), y** **Delay [range], m**	**Passive ROM [range] or (SD), deg** **Motricity strength in MRC scale, AROM in deg**	**Muscle hypertonia [range] or (SD)** **Dynamic muscle activation (visual or EMG)**	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow up [range]**	**RESULTS**		
								Clinical examination	**Autonomy /Gait**	**Complications/ recurrence (REC)**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Barouk 1989 R, CS 0/16	CT-l (21; 43%) FD-r (-) Subtalar and midtarsal arthrodesis (7/21)	TBI (35) Feet (49) 24 [17-45] [12-24]	EVF (important equinus) NS	NS NS	NS NS	NS	1-14 y	NS	NS	With CT-l - 6 equinus REC - 10 Varus
Roper *et al.* 1978 R, CS 3/16	CT-l (14; 38%) FDL-r (if claw toes) (NS) TP-l if hindfoot varus (when varus in SwP not only due to TA activity) (NS)	Stroke or TBI (37) 43 [18-72] NS	ADF-KE= [-60/-30] ADF-KF= [-50/-10] (n=33 tested) AROM-KF in neutral position needed to realize CT-l on its own	Spastic NS	NS NS	Tibial nerve often performed	NS	No equinus AROM = 10 (n=33 tested)	No chairbound ↕walking aids for 18 ↕orthosis for 14	No REC
Fried *et al.* 1961 R, CS 0/16	CT-l (8; 100%) FDL-l, FHL-l, TP-l (8/8)	Stroke (8) Significant medical comorbidities Elderly NS	Equinus and varus NS	Spastic NS	NS NS	NS	3 y	NS	NS	No REC Overcorrection/calcaneal walking for 1
Giannotti *et al.* 2016 R, CS 7/16	CT-l (12; 25%) FDB-r (5/12) Or FDL/FHL-l (5/12)	Stroke (47) 56 (15) 72 (60)	EVF NS	No spastic dystonia, no history of STN, no BTI in the past 12 m NS	Laboratory gait analysis ADF-IC= -10 (8) ADF-StP = 4 (10) ADF-SwP = -8 (9) Walking >10 m barefoot (study design)	NS NS	1 m	NS	No ≠ in spatio-temporal parameters and speed except step width, double StP on healthy side ADF-IC= -1 (4) * ADF StP = 11 (6) * ADF SwP = 5 (7) * Linear correlation between preoperative	NS

Authors Date Type MINORS score	Surgery (number; % of total) Additional surgery	Pathology (total population) Age [range] or (SD), y Delay [range], m	Passive ROM [range] or (SD), deg Motricity strength in MRC scale, AROM in deg	Muscle hypertonia [range] or (SD) Dynamic muscle activation (visual or EMG)	Instrumental or visual kinematic gait analysis Autonomy	Botulinum toxin injection (BTI) or nerve block (NB)	Length of follow up [range]	RESULTS		
								Clinical examination	Autonomy /Gait	Complications/ recurrence (REC)
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
									and postoperative values *	
Giannotti *et al.* 2018 R, CS 8/16	CT-l (6, 25%) FD-r (6/6)	Stroke (24) 55 (13) 60 (36)	EVF NS	No spastic dystonia, no history of STN, no BTI in the past 12 m NS	Laboratory gait analysis ADF-StP= 5 (9) ADF-SwP= -6 (15) ADF-IC= -11 (14) Walking >10 m barefoot (study design)	NS	12 m	NS	↑ADF-StP= 11 (9) * ↑ADF-SwP= 3 (6) * ADF-IC= -4 (5) * ↑speed * (but still low, can be attributed in a lack of propulsion on weakness of plantar flexors)	No REC
Redfern & Thordarson 2008 R, CS 4/16	CT-l (6; 100%) TP-l (6/6)	MS (4) Stroke (1) Other (1) Significant medical comorbidities 59 [55-73] 75.6 [7-180]	ADF =-30 [-20/-45] Varus= -9 [-15/0] Fixed deformity NS	NS NS	NS Minimally ambulatory / wheelchair	NS	NS	ADF= 0 [0/0] Varus = 2.5 [-5/5]	↑ambulatory status if ambulatory in preoperative Transfer facilitated	No REC No flat foot
Waters *et al.* 1982 R, CS 7/16	CT-l (4; 15%) FDL-r (4/4) FHL-r (4/4)	Stroke (20) TBI (5) Other (2) [22-68] Stroke > 6 m TBI >18 m	4 equinus w/o varus (SPLATT when varus) NS	Clonus on Sol (19/27) & GM (18/27) Dynamic EMG *(Si/Con /PP/N)* GM 0/6/21/0 SOL 0/2/24/1	NS Walking at least 6 meters for gait analysis	NS	> 6 m	Clonus on Sol (16/19) & GM (14/18)	Dynamic EMG *(Si/Con /PP/N)* GM 1/7/18/1 Sol 1/2/24/0 Same pattern	
Benedetti *et al.* 2011	CT-l (2; 15%)	Stroke (11) TBI (2)	EVF Claw toes	NS	Laboratory gait analysis:	NS	4 m	NS	FAC = 4.3 (0.6) * ↕ orthosis: 4	No REC

Authors **Date** **Type** **MINORS score**	**Surgery (number; % of total)** **Additional surgery**	**Pathology (total population)** **Age [range] or (SD), y** **Delay [range], m**	**Passive ROM [range] or (SD), deg** **Motricity strength in MRC scale, AROM in deg**	**Muscle hypertonia [range] or (SD)** **Dynamic muscle activation (visual or EMG)**	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow up [range]**	**RESULTS**		
								Clinical examination	**Autonomy /Gait**	**Complications/ recurrence (REC)**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
R, CS 6/16	FDL-r (2/2) FHL-r (1/2)	 51 [19 -74] NS	NS	NS	ADF-IC = -15.6 (13.8) ADF-StP = -5.7 (14.2) ADF-SwP = -25.5 (14.5) Varus-SwP = 22.5 (17.6) FAC = 3.5 (0.8) All walkers (study design)				↕ cane: 2 *No ≠ in spatio-temporal parameters* ADF-IC= -10.3 (7) * ADF-StP= 4.4 (6.6) * ADF-SwP= -12 (7.6) * Varus-SwP = 16.7 (9) *	
Boffeli & Collier. 2014 CR 5/16	CT-l (1) TP-l (1/1) FDL/FHL-r (1/1)	Stroke (1) 61 144	Equinus Varus Claw toes Fixed deformity NS	Spastic NS	No heel contact Walk with an AFO	NS	22 m	AROM allow ADF = 0 (activation of TA)	Pain relief Patient satisfied ↕ AFO at home	No REC

(Dynamic EMG: Con=continuous; Si =silent; N= normal or In Phase; PP= premature and/or prolonged phasic; Opp= opposite or Out of Phase)

Table S3. Detailed content of articles concerning tibial anterior transfer

Authors **Date** **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion**)	**Additional surgery** (n/total) (goal)	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range] or (SD)	**RESULTS** **Clinical examination** **Autonomy /Gait**	**RESULTS** **PROM / Deformity** **Recurrences (REC)/ Reoperation**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Keenan *et al.* 1999 RCT 20/24	SPLATT (67; 100%) **on cuboid** *group I: w/o FDL/FHL-t* *group II: with FDL/FHL-t*	CT-l (67/67) FD-r (67/67) EHL-l (12/67) TP-l (28/67) FHL/FDL-t to calcaneum (36/67)	Stroke (22) TBI (28) Others (5) 67 feet 38 [11-80] 32 [17-53]	NS NS	UMNS for all Activation on dynamic EMG: **TA:** *Con* 8 / *Opp* 18 / *PP* 26 / *N* 15 / *Si* 0 **TP:** *N* 23 / *PP* 28 / *Si* 16 **FDL/FHL:** none *Si* or *Opp* and mostly *Con* **Peroneal:** some *Si* and mostly *PP*	Laboratory gait analysis performed for all but NS Independent ambulator: 30 Standby assist: 4 Maximal assist: 10 Transfer only: 11 Orthoses for all	NS	13 m	No ≠ of dynamic EMG when done ↕ orthoses for 10 (40%) VS 21 (70%) in group II * (orthoses continued when calf weakness) ↑ ambulatory status (93% for group II VS 64% for group I) * ↑ speed (measured in group II) *	REC Varus & claw toes = 0 Equinus = 0 in group I and 2 in group II (when walking)
Pinzur *et al.* 1986 R, Cp 9/24	TA-t (54; 100%) **on 2nd or 3rd cuneiform** => entire tendon to ↑ ADF and to correct varus forefoot & hindfoot *group A: w/o TP-l* *(group B: with TP-l*	CT-l (54/54) FHL-l (54/54) FDL-l (54/54) FHB-r (42/54) TP-l (12/54) (out of phase activation of TP in SwP)	Stroke (31) TBI (16) Others (7) 43 [17-77] 38 [12-204]	NS NS	Spastic EMG for 27 patients followed up (Con/Opp/ N) **TA:** 0 / 23 / 4 **TP:** 2 / 4 / 21 **TS:** 17 / 2 / 8 **Peroneal:** 0 / 0 / 27	Laboratory gait analysis performed for all but described for the 27 patients followed up: Type I (dynamic varus deformity): 4 Type II (spastic and dynamic EVF and recurvatum compensation by flexion of the hip and knee): 19 Type III (type II more severe): 4 ADF SwP -15 ADF-StP= 1 Orthoses 45/54 (84%)	Phenol of TN sometimes but insufficient to correct the EVF	30 m [24-62]	No ≠ of dynamic EMG when done Orthoses 22/54 (41%) (↕ orthoses for 13 patients) - ↑ in spatio-temporal parameters - ↑ kinematics but not normal (greatest improvement in type III patient in spatio-temporal and kinematics) Type I: 14 Type II: 10 Type III: 3 ADF SwP= -2 ADF-StP= 6 ↕ recurvatum No ≠ between group A and group B	↕ equinus for all No dynamic varus of forefoot 8 heel toe gait 2 pullout tendon reoperated

Authors **Date** **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion**)	**Additional surgery** (n/total) (goal)	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range] or (SD)	**RESULTS** **Clinical examination** **Autonomy /Gait**	**PROM / Deformity** **Recurrences (REC)/ Reoperation**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Hosalkar *et al.* 2008 R, Cp 15/24	SPLATT (47; 100%) **on cuboid** *Comparison between 2 fixation techniques*	CT-l *(NS)* TP-l *(NS)* FHL-FDL-t on calcaneum *(NS)* FD-r *(NS)* EHL-t on 2nd cuneiform *(NS)* PFR*(NS)* = surgery depends on dynamic EMG and clinic	TBI (47) 43 [29-67] 31 [18-66]	EVF NS	NS Dynamic EMG (Con/Si/ PP/ N) **TA :** 27 / 1 / 19/ 0 **TP :** 8 / 19/ 18/ 2 **SOL**: 11/ 10 / 26/ 0 **Peroneal :** 4/ 3 / 40/ 0 **FDL :** 16 / 7 / 24/ 0 **FHL :** 29/5/12/3	NS Orthoses 39 Orthoses not fit 8 Walking 47	NS	40 m [24-84]	↕ orthoses for 77% * (continued when calf weakness, spasticity or proprioception deficit) ↑ of the FAC score *	Plantigrade position for all No REC 3 pullouts in first technique
Carda *et al.* 2010 R, Cp 17/24	SPLATT (15; 52%) **on cuboid** *Group I: SPLATT 15/29* *Group II: EHL-t 14/29*	CT-l (15/15) FDB/FDL-r (15/15)	Stroke (29) 50 [20-67] 61 [14-123]	ADF-KE <0 (w/ or w/o varus) Fixed contracture on plantar flexion NS	No inclusion when clonic activity in the StP and/or SwP, spastic dystonia or requiring BTI /phenol block/STN in calf muscle (no BTI in the last 9 m) Overactivity of TA in SwP and no overactivity of TP (or contracture) (at clinic or dynamic EMG)	Forefoot varus in SwP and IC (indicates transfer, SPLATT or EHL) Laboratory Gait analysis ADF-SwP= -12,2 [-24,4/-0,4] Walking >10 m barefoot (study design) Orthoses 4/15	NS	12 m	ADF-SwP = - 8,43 [-22,5/8] (*No ≠**) ↑speed * ↑paretic propulsion * ↑walking handicap score * Orthoses 0/15	No REC of varus in SwP
Deltombe *et al.* 2018 P, CS 11/16 *	SPLATT (2; 11%) **on fibular brevis**	GM-apo + FDL-l (1/2) CT-l + FDL-l + FHL-l (1/2)	Stroke (18) 56 (11) > 6	ADF= -9 (12) *MRC* TA= 0,5 [0-3] TS= 0,5 [0-3] *AROM* *ADF*= -19 (13)	*Tardieu:* TS-KE= 2,5 [1-4] TS-KF= 3 [1-3,8] *MAS:* TS-KE= 3 [2-4] TS-KF= 2,5 [2-3] For transfer, TA activation in SwP needed + imbalance between TA & peroneus	Video assessment (double blinded assessor) ADF-SwP= -26 (10) ADF-StP= -16 (10) Walk 10 m Orthoses 5/18	TN branch for all	12 m	No ≠ in MRC or in AROM ↕ orthosis for 5 ↑ Speed barefoot (after 3 months) * (no ≠ with aids) ↓equinus in SwP &StP* No ≠ in activities (FAC) or participation	↑ PROM (ADF= 5) * ↓ of TS (KE & KF) spasticity * No REC

Authors **Date** **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion**)	**Additional surgery** (n/total) (goal)	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range] or (SD)	**RESULTS** **Clinical examination** **Autonomy /Gait**	**PROM / Deformity** **Recurrences (REC)/ Reoperation**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Vogt *et al.* 2011 R, CS 7/16	SPLATT (132; 100%) **on cuboid**	CT-l (129/132) FDB/FDL-r (118/132) EHL-l (12/132) TP-l (4/132) FDL-t to calcaneum (1/132) (severe paresis of TS) Subtalar arthrodesis (1/132) (correct flat foot in StP) Hallux MTP arthrodesis (4/132) DMMO (1/132)	Stroke (80) TBI (25) Other (25) 132 feet 46,7 [11-78] 79 [13-486]	Claw toes for 123 Distal muscular control for 33/82 (reviewed patients)	Spastic EVF NS	Lack of knee and hip flexion n=71 Visual analysis of foot position but NS OS 107/132 Orthoses 76/132 Walking: outdoors 59 indoors 39 with assistance 10 bedridden 22	NS	65 m 82 patients 84 feet	↑ FAC * Orthoses 12/76 (↕ for 84%) * OS 10/107 (↕ for 91%) * Correlation between proprioceptive disorder and FAC * No correlation between voluntary muscular control and FAC	- 6 transfer rupture (=>Bardot surgery) - REC Varus= 1 (=>TP-r) Claw toes= 2 (=> IP arthrodesis) - 4 new clawtoes when no FD-r pre-op (=> FDB-r) - 1 hallux hyperextension (=> EHL-l) - 1 valgus on late recovery of peroneals function on TBI (=> loosening SPLATT)
Mooney & Goodman 1969 R, CS 1/16	SPLATT (84, 69%) **on 3rd cuneiform**	CT-l (82/84) when spasticity or contracture FD-r (84/84) ± TP-l when spasticity or contracture	Stroke (122) 55 [17-84] NS	Equinus: contracture or spasticity Varus indicates SPLATT NS	Equinus: contracture or spasticity NS	NS NS	NS	6 m	Better result if selective motor control ↑ Functional level ↕ Technical aids 10/84	Incomplete correction of varus (pullout of tendon transfer) =6 ↑ Valgus in StP due to Absence of TP activity = 15
Vogt *et al.* 1998 R, CS 8/16	SPLATT (73; 100%) **on cuboid**	Alone (9/73) FDB-r (6/73) CT-l (9/73) CT-l and FDB-r (49/73) (with 1 TP-l)	Stroke (42) TBI (15) Others (12) 73 feet 46,5 [8-79] 50	Varus indicates SPLATT ADF ≥ 5 (obtained with CT-l) 62 equinus 73 varus 37 claw toes	NS NS	NS OS 47/73 (68%) Orthoses 39/73 (57%) Walking outdoors 31 indoors 26 bedridden 12	NS	44 m [12-168] 48 patients reviewed	Well balanced foot for 49/73 OS 4/47 (↕ for 91%) * Orthoses 9/39 (↕ for 77%) * ↑ functional status for 52, stable for the others *	- 4 varus remaining - 5 rupture/ necrosis of transfer (no CT-l performed for 3 of them) (=> 3 Bardot technique) - 9 varus in SwP - REC equinus=6 (=> 1 phenolization of GM, 1 CT-l) - 6 claw toes

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								Statistically different* (if not mentioned, no statistical difference or not assessed)		
				NS						
Namdari *et al.* 2009 R, CS 9/16	SPLATT (64; 100%) **on cuboid or 3rd cuneiform**	FDL-t to calcaneum (61/64) (FDL not spastic, not contracted and TS weakened => to ↑ strength of TS) CT-l (58/64) PFR (56/64) TP-l (30/64) EHL-l (7/64) EHL-t on cuboid (39/64) => plantigrade position	Stroke (64) 54 [24-74] 66 [17-523]	Equinovarus No bone deformation NS	Spastic Laboratory gait analysis and dynamic EMG but NS	Laboratory gait analysis and dynamic EMG but NS Orthoses 48 Assistive device 23 Walking outdoors 29 indoors 22 bedridden 13	NS	12 m [3-42]	↕ orthoses for 21 (44%) * ↕ assistive device for 11 (48%) * ↑ ambulation score (Viosca score) * (but no correlation with age, sex or delay)	Plantigrade position for all
Keenan *et al.* 1984 R, CS 8/16	SPLATT (59; 100%) **cuboid and 3rd cuneiform**	CT-l (53/59) (equinus) TP-l (1/59) (if continuous activity at EMG and severe hindfoot varus) FDL-r (52/59) (to prevent/correct claw toes) FHL-t (18/59) (support SPLATT and correct forefoot varus, activity in SwP at EMG) FHL-r (34/59)	TBI (54) 59 feet 25 [14-50] 35 (26)	Forefoot varus NS	NS Dynamic EMG on 33 n (Con/Si/ PP/ N) **TA:** 16 / 1 /16 / 0 **TP :** 6 /12 / 14 / 1 **SOL :** 8 / 4 / 21 / 0 **GM :** 12/ 6 / 15/ 0 **FDL :** 8 / 5 / 20 / 0 **FHL :** 15 / 5 / 12/ 1 **Peroneal :** 2 / 2 / 29 / 0	NS 32 ambulator 7 standby assist 15 bedridden 25 orthoses in walkers' group	NS	50 m (23)	36% of the walkers ↕ orthoses ↑ ambulation score (40 ambulator, 8 standby-assist, 6 bedridden) No ≠ when complementary FHL-t versus SPLATT alone on autonomy (young age?)	Plantigrade position for all

Authors **Date** **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion**)	**Additional surgery** (n/total) (goal)	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range] or (SD)	**RESULTS** **Clinical examination** **Autonomy /Gait**	**RESULTS** **PROM / Deformity** **Recurrences (REC)/ Reoperation**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Tracy *et al.* 1976 R, CS 6/16	SPLATT (35; 100%) **on 3rd cuneiform**	CT-l (35/35) TP-l (35/35) FD-r (35/35)	Stroke (22) TBI (8) Other (5) 40 [18-62] 46	NS if selective contraction of TA, better result but not systematic	NS NS	Extensor synergy (hip and knee extension, plantar flexion and strong inversion of the heel in SwP) Orthoses 32/35 Chairbound 3/35	NS	32 m [4-73] No Stat	All patients who achieved satisfactory postoperative foot dorsiflexion had been able to contract the tibialis anterior selectively at will or had shown tibialis anterior activity in the preoperative evaluation.	- 1 deformity REC needing orthoses - 1 TS weakness needing orthoses (spastic before surgery, hide weakness) - 1 case of hindfoot eversion- forefoot pronation - 3 REC of claw toes not symptomatic - 3 equinus in SwP (TA has a tenodesis effect)
Carda *et al.* 2009 R, CS 7/16	SPLATT (33; 19%) **on cuboid**	GM-apo or CT-l (33/33) FDL-l (33/33) ± FDL-t on calcaneum	Stroke (177) 49,7 (14) 67,2 (89,5)	ADF-KE ≤ 0 Varus indicates transfer NS	No clonic activity in the StP and/or SwP, no spastic dystonia and no requiring botulinum toxin/phenol block/selective neurotomy in calf muscle (no BT in the last 9 m) NS	Laboratory Gait analysis ADF-StP = -0,77 (9) ADF-SwP = -6,1 (11) Walking >10 m barefoot (study design) Walking with: assistance or aids 112 Orthosis 28	NS	12 m	↕ Orthosis 22/28 ↕ assistance/ aids for 18/112 (16%) ↑ walking handicap score * ↑ of kinetics parameters on paretic side and speed ↓ plantarflexion moment peak * ADF-StP = 2,4 (7) * ADF-SwP = 4,3 (10) *	REC of claw toes = 3
Lemos. 2011 R, CS 8/16	SPLATT (27; 100%) **on cuboid**	CT-l (equinus) (27/27) FDL/FHL-r (claw toes) (26/27) TP-l (often involved in varus) (NS) => lengthening of tendons when they are retracted/ or overactive	Stroke (21) TBI (6) 49 [18-72] 84 [24-64]	varus indicates SPLATT 26 EVF+ claw toes 1 equinus Fibular paresis often	NS TA usually overactive	NS Orthoses 25/27	NS	29 m [12-84]	↕ orthoses 100%	Loss of propulsive force = 6

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								Statistically different* (if not mentioned, no statistical difference or not assessed)		
				involved in varus						
Reddy *et al.* 2008 R, CS 9/16	SPLATT (26; 100%) **on cuboid**	CT-l (26/26) FDB-r (26/26) FDL-t to calcaneum (26/26) (to strength weak TS) TP-l (NS) (if abnormal activity) EHL-t (NS) (if EHL overactive, to help SPLATT)	Stroke (26) 54,7 [23-72] 74	varus indicates SPLATT NS	Spasticity of TS and FDL Overactivity of TA at dynamic EMG indicates SPLATT	NS Orthoses 100% FAC= 3,0 (1,1)	NS	18 m [6-48]	↕ Orthoses 61% ↑ FAC = 3,5 (1,7) *	
Edwards *et al.* 1993 R, CS 7/16	SPLATT (24; 100%) **on cuboid**	CT-l (23/24) TP-l (5/24) (if incomplete correction with CT-l) PFR (3/24) (forefoot equinus) Triple arthrodesis (2/24) (bone deformation) § FHL-t to the cuboid (4/24) FD-r (21/24)	TBI (9) Stroke (9) Other (3) 24 feet 41 [18-67] 34	23 fixed deformation NS	NS Dynamic EMG often performed but NS § activation of FHL at EMG	1 dynamic equinovarus 3 non-ambulatory 1 ambulatory with assistance 17 ambulatory with orthoses	NS	39 m [12-79]	↕ orthoses for 35% ↑ ambulatory statues. Poor surgical outcomes correlated to low ambulatory statues * Results 6 excellent 14 good 4 bad	4 REC: - transfer rupture (=>Bardot technique) - recurrent varus because of claw toes (=> triple arthrodesis+ FD-r) - 2 claw toes (=> FDB-r)
Waters *et al.* 1982 R, CS	SPLATT (23; 85%) **insertion NS**	CT-l (27/27) § FDL-t (1/27) or FHL-t (8/27) or FDL-t + FHL-t (1/27) §§ TP-t (1/27)	Stroke (20) TBI (5) Other (2) [22-68]	- 23 EVF - 4 equinus w/o varus - SPLATT when varus	Clonus on Sol (19/27) & GM (18/27) Dynamic EMG **TA:** *Con* 16 / *N* 2 / *PP* 5 **GM:** *Con* 6 / *PP* 21	§ if activation of FDL in SwP transfer, if not tenotomy §§ if activation of TP in SwP and not FDL	NS	> 6 m	Pattern of TA activation still the same (and for the other muscles) Authors opinion: they experiment failure when insufficient tonus of TA	Clonus on Sol (16/19) & GM (14/18)

Authors **Date** **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion**)	**Additional surgery** (n/total) (goal)	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range] or (SD)	**RESULTS** **Clinical examination** **Autonomy /Gait**	**RESULTS** **PROM / Deformity** **Recurrences (REC)/ Reoperation**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
7/16		TP-t & FDL/FHL-t => reinforce SPLATT FDL/FHL-r (12/27) when no FDL/FHL-t & no TP-t	Stroke > 6 TBI >18	NS	**SOL:** *Con* 2/ *PP* 24 / *N* 1 **FDL** when transfer: *Con* 2 **FDL** when tenotomy: *Con* 11 / *N* 2 **FHL** when transfer: *Con* 9 **TP** when transfer: *Con* 1	Walking at least 6 meters for gait analysis			or active contraction of TA absent, that's why they consider reinforcing SPLATT by FDL	
Roper *et al.* 1978 R, CS 3/16	SPLATT (23; 62%) **on 2nd cuneiform**	CT-l (37/37) FD-r (NS) TP-l (NS) (when varus of hindfoot in SwP not only due to TA activity)	Stroke or TBI (37) 43 [18-72] NS	N=33 tested Fixed equinus ADF-KE = [-30 to -60] ADF-KF = [-10 to -50] NS	Spasticity NS	Recurvatum for 5 Lack of knee flexion for 7 (video gait analysis) NS	TN block often used	NS	↕ Recurvatum Knee flexion restored for 5/7 No fixed APF AROM about 10° Less technical aids	No REC
Martin *et al.* 1989 R, CS 3/16	SPLATT (23; 100%) **on cuboid or fibular brevis when cuboid seems fragile** (transfer provide active ADF & lateral stability of the foot)	CT-l (19/23) (to obtain 10° of ADF) FDB/FDL-r (19/23) (+1 few months later)	Stroke or TBI (17) Others (6) 37 [13-64] 48 [6-336]	Hindfoot varus passively reducible 23 Varus 19 Equinus 13 Claw toes Strong contraction of TA (in triple flexion)	NS EMG useful (not detailed)	NS Orthoses or OS 17	NS	34 m [4-72]	↑ambulatory status 20 No change for 3 (not limited in preop for 1 and severe paresis on TA or spasticity for 2) Orthoses or OS 5	REC Equinus = 5/19 (visible in SwP, on TA weakness or on TS spasticity) Varus = 8/23 Claw toes = 6/13 (FDB retraction)

Authors **Date** **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion**)	**Additional surgery** (n/total) (goal)	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range] or (SD)	**RESULTS** **Clinical examination** **Autonomy /Gait**	**RESULTS** **PROM / Deformity** **Recurrences (REC)/ Reoperation**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
Gasse *et al.* 2012 R, CS 2/16	SPLATT modified (with Bardot technique/ tenodesis with fibular brevis) (22; 100%) **on 5th MT**	CT-l (White) § or GM-apo (Baker)§§ => to obtain ADF > 10° (22/22)	Stroke (14) TBI (4) Other (4) 40 [17-76] NS	EVF equinus KE and KF § or only KE§§ NS	NS NS	NS NS	NS	>2 y	NS	2 REC
Morita et al. 1998 R, CS 9/16	TA-t (15; 12%) **on 3rd cuneiform**	When TA-t : GM-apo (15/15) FDL-r (15/15) FDB-r (3/15) (severe hammertoes)	Stroke (125) 61 [42-78] 23 [6-132]	EVF BRS 1: 0 BRS 2: 0 BRS 3: 9 BRS 4: 4 BRS 5: 2 BRS 6: 0	BRS visual gait analysis: strong activation of TA in SwP	NS Walking Outdoors 10/15 Indoors /15, With assistance 4/15 Orthoses 15/15	NS	33 m [24-74]	8/15 (53%) walk w/o orthoses ↑ ambulatory status	5/15 (33%) drop foot even if strong contraction of TA before (orthoses always needed) REC Varus = 2/15 (13.3%) (not due to activity of TA) Claw toes = 6/15 (40%)
Giannotti *et al.* 2016 R, CS 7/16	SPLATT (10; 21%) **insertion NS**	CT-l (10/10) FD-r (10/10) FHL-t (anterior transfer) (10/10)	Stroke (47) 56 (15) 72 (60)	EVF NS	No spastic dystonia, no history of STN, no BTI in the past 12 m NS	Laboratory gait analysis ADF-IC = -10 (8) ADF-StP = 4 (10) ADF-SwP = -8 (9) walking >10 meters barefoot (study design)	NS	1 m	No ≠ in spatio-temporal parameters and speed except step width, double StP on healthy side ADF-IC = -1 (4) * ADF-StP = 11 (6) * ADF-SwP = 5 (7) * Linear correlation between pre-op. and post-op. values *	NS

Authors **Date** **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion**)	**Additional surgery** (n/total) (goal)	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range] or (SD)	**RESULTS** **Clinical examination** **Autonomy /Gait** Statistically different* (if not mentioned, no statistical difference or not assessed)	**RESULTS** **PROM / Deformity** **Recurrences (REC)/ Reoperation**
Giannotti *et al.* 2018 R, CS 8/16	SPLATT (9; 38%) **insertion NS**	CT-l (9/9) FD-r (9/9) Anterior FHL-t (2/9) EHL-t on 4th MT + anterior FHL-t (1/9)	Stroke (24) 55 (13) 60 (36)	EVF NS	No spastic dystonia, no history of neurotomy, no injection of BTI in the past 12 m NS	Laboratory gait analysis ADF-StP= 5 (9) ADF-SwP= -6 (15) ADF-IC= -11 (14) walking >10 meters barefoot (study design	NS	12 m	ADF-StP= 11 (9) * ADF-SwP= 3 (6) * ADF-IC= -4 (5) * ↑speed * (but still low, can be attributed in a lack of propulsion on weakness of plantar flexors)	No REC
Barouk 1989 R, CS 0/16	SPLATT (8; 16%) **on fibular brevis**	CT-l (8/8) Often FDB/FDL-r or IPP arthroplasty Hallux IPP arthrodesis	TBI (35) Feet (49) 24 [17-45] [12-24]	EVF (important equinus) NS	NS NS	NS NS	NS	1-14 y	NS	Varus 2 (insufficient tensioning, 1 corrected 14 y later) Valgus 1 (excessive tensioning)
Benedetti *et al.* 2011 R, CS 6/16	SPLATT (6; 46%) TA-t (2; 15%)	SPLATT w/ CT-l (4/6) SPLATT w/o CT-l (2/6) TA-t w/ CT-l (2/6) FDL-r (4/6) FHL-r (2/6) TP-l (1/6)	Stroke (11) TBI (2) 51 [19-74] NS	EVF Claw toes NS	NS NS	Laboratory Gait analysis: ADF-IC= -15.6 (13.8) ADF-StP= -5.7 (14.2) ADF-SwP= -25,5 (14,5) Varus-SwP= 22.5 (17.6) FAC = 3,5 (0,8) All walkers (study design)	NS	4 m	FAC = 4,3 (0,6) * ↕ orthosis: 4 ↕ cane: 2 No ≠ in spatio-temporal parameters or speed ADF-IC= -10,3 (7) * ADF-StP= 4,4 (6,6) * ADF-SwP= -12 (7,6) * Varus-SwP = 16,7 (9) *	No REC
Yamamoto *et al.* 1992 R, CS	TA-t (5; 7%) **insertion NS**	GM-apo (equinus) (5/5) FD-r (claw toes) (5/5)	Stroke (75) 57	EVF Claw Toes	none stage 1 => all patients develop spasticity	NS Orthosis 5	NS	6,4 y	↕ Orthoses 2/5 Autonomy not related to operative technique but to age, degree of paralysis	REC in SPLATT group= 0

Authors Date **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion**)	**Additional surgery** (n/total) (goal)	**Pathology** (total population**)** **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** [range] or (SD) **Dynamic muscle activation** (visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up** [range] or (SD)	**RESULTS**	
									Clinical examination **Autonomy /Gait**	**PROM / Deformity** **Recurrences (REC)/ Reoperation**
								Statistically different* (if not mentioned, no statistical difference or not assessed)		
10/16			18	Varus indicates transfer BRS 1: 0 BRS 2: 0 BRS 3: 4 BRS 4: 0 BRS 5: 1 BRS 6: 0	Strong active contraction in SwP			(4/5 reassessed)	and speed gait at discharge	

(Dynamic EMG: Con=continuous; Si =silent; N= normal or In Phase; PP= premature and/or prolonged phasic; Opp= opposite or Out of Phase)

FAC: ambulation functional scale

Table S4. Detailed content of articles concerning lengthening of anterior Tendon transfer (except SPLATT)

Authors Date **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion)**	**Additional surgery** (n/total) (goal)	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** **Dynamic muscle activation** (Visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up**	**RESULTS** **Clinical assessment** **Autonomy, orthosis** **Kinetics, kinematics** Statistically different OR *No statistical difference* (when mentioned)	**Complications/ Recurrences (REC)**
Carda *et al.* 2010 R, Cp 17/24	EHL-t **on 4th MT** (n=14; 48%) => alternative of SPLATT when no activity of TA is found *Group I SPLATT 15/29* *Group II EHL-t 14/29*	With EHL-t: CT-l (14/14) FDL-r (14/14) FDB-r (14/14)	Stroke (n=29) 51 [32-70] 82 [19-164]	ADF-KE <0 (w/ or w/o varus) Fixed contracture on plantar flexion NS	No inclusion when clonic activity in the StP and/or SwP, spastic dystonia or requiring BTI/ phenol block/ STN in calf muscle (no BTI in the last 9 m) No overactivity of TA and overactivity of EHL in SwP and StP (clinic and EMG)	Forefoot varus in SwP and IC (indicates transfer, SPLATT or EHL) Laboratory Gait analysis ADF-SwP = -16,7 [-20,2/5,1] Walking >10 m barefoot (study design) Orthosis 2/14	NS	12 m	NS Orthosis 0/14 ↑ speed * ↑ paretic propulsion * ↑ walking handicap score* ADF-SwP = - 9,7 [-15,1/13,8] *	No REC of varus in SwP
Morita *et al.* 1998 R, CS 9/16	FDL/FHL-t **on 4th MT** (n=110, 88%) => alternative of TA-t because risk of paresis and foot drop after TA-t	With FDL/FHL-t: GM-apo (110/110) FDB-r (15/110 if severe claw toes) TP-l (8/110 if severe varus)	Stroke (n=125) 57 [32-75] 23 [6-132]	EVF BRS 6: 0 BRS 5: 0 BRS 4: 28 BRS 3: 81 BRS 2: 1 BRS 1: 0	BRS NS	Kinetics analysis Walking: Outdoors 42/110 Indoors 28/110 With assistance 40/110 Orthosis 110/110	NS	33 m [24-74]	NS 83/110 (75 %) walk w/o orthoses ↑ ambulatory status ↑ kinetics values on force plate and speed gait	REC Varus = 17 (15.5%) (not due to activity of TA) Claw toes = 21 (28.2%)
Carda *et al.* 2009 R, CS 7/16	EHL-t **on 4th MT** (n= 57) or **on 3rd MT** (n= 14) => to correct varus FHL-t **on 4th MT** (n=13) => to invert the pull of FHL from plantarflexor to dorsiflexor	For all CT-l or GM-apo FDL-l ± FDL-t on calcaneum ± TP-l	Stroke (n=177) 49,7 (14) 67,2 (89,5) (>12 m)	ADF-KE ≤ 0 Varus indicates transfer NS	No clonic activity in the StP &/or SwP, no spastic dystonia & no requiring BTI / phenol block/STN in calf muscle (no BTI in the last 9 m) NS	Laboratory Gait analysis ADF-StP = -0,77 (9) ADF-SwP = -6,1 (11) Walking >10 meters barefoot (study design) Walking with: assistance or aids 112 Orthosis 28	NS	12 m	NS ↕ Orthosis 22/28 ↕ assistance/ aids for 18/112 (16%) ↑ walking handicap score* ↑ of kinetics parameters on paretic side and speed *	REC of claw toes = 3

Authors **Date** **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion)**	**Additional surgery** (n/total) (goal)	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** **Dynamic muscle activation** (Visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up**	**RESULTS**	
									Clinical assessment **Autonomy, orthosis** **Kinetics, kinematics**	**Complications/ Recurrences (REC)**
									<u>Statistically different</u> OR *No statistical difference* (when mentioned)	
									↓ plantarflexion moment peak * ADF-StP = 2,4 (7) * ADF-SwP = 4,3 (10) *	
Yamamoto *et al.* 1992 R, CS 10/16	TP-t (n=3; 4%) FDL-t anterior (n=41; 55%) => to correct varus and claw toes	With transfer: GM-apo	Stroke (n=75) 57 18	Varus + TP contraction in StP when TP-t Varus + claw toes when FDL-t BRS TP-t/FDL-t BRS 2= 0/1 BRS 3= 2/26 BRS 4=1/14 BRS 5= 0/0 BRS 6=0/0	Only 1 patient Almost all patients develop spasticity (cf BRS) TP contraction in StP when TP-t (discussion) FDL known to contract in SwP (discussion, Waters)	NS Orthosis 44	NS	6,4 y (1/3 reassessed in TP-t group & 28/41 in FDL-t group)	NS Orthosis continued for 4 in FDL-t group because severe paresis Autonomy not related to operative technique but to age, degree of paralysis and speed gait at discharge NS	REC in TP-t group= 0 REC in FDL-t group = 5 (18%) claw toes (hypothesis of FDB spasticity)
Curvale *et al.* 1999 R, CS 7/16	Bardot intervention (distal tendon of peroneus brevis attached **on tibialis anterior**) (n= 41, 100%) => to revive eversion	CT-l (41/41) FD-r (41/41) FHL-r (41/41) STN or phenolization for 13 before this surgery but was insufficient	Stroke (n=30) TBI (n=8) Others (n=3) 46 [27-73] NS	Varus totally reducible and equinus at least partially not reducible MRC TA ≥4 in triple flexion No voluntary or syncinetic activation of fibular (contraindication if present)	Spasticity TA contraction in SwP (visual) Claw toes 38/41 (93%)	Varus in StP (stable 15, instable 26) Dynamic EVF in SwP No heel contact at IC 4 lack of knee flexion in SwP All walkers with or w/o aids With Cane or Orthosis: 33/41 (80.5%)	NS	40 m [12-108]	NS Walk with Cane or Orthosis: 2/41 (5%) Lack of Knee flexion persist in SwP for 4 No varus instable Initial heel contact for 27/41 (65.8%)	- No talus - Varus = 7 (17%) remained or recurred (on recurrence of spasticity or on transplant loosening) - Claw toes REC= 6/38 (15%) - Mild Equinus in SwP remained = 6/41

Authors **Date** **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion)**	**Additional surgery** (n/total) (goal)	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** **Dynamic muscle activation** (Visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up**	**RESULTS**	
									Clinical assessment **Autonomy, orthosis** **Kinetics, kinematics**	**Complications/ Recurrences (REC)**
									Statistically different OR *No statistical difference* (when mentioned)	
Ono *et al.* 1980 R, CS 4/16	FDL/FHL-t (n= 39, 100%) on **4th MT**	GM-apo (Baker) (39/39)	Stroke (n=32) TBI (n=1) Others (n=6) Adults (children excluded for the review) > 12	EVF + Claw toes When no flexion of the toes (voluntary movement or not) = contraindication of this surgery Flaccidity of calf muscle is a contraindication	Spastic deformity Claw toes = static (fixed toe flexion) or dynamic in SwP (visual or EMG) or when syncinetic movement or when wearing shoes	Claw toes = static (fixed toe flexion) or dynamic in SwP (visual or EMG) or when syncinetic movement or when wearing shoes NS	NS	4 to 8 y	No voluntary ADF after transfer but tenodese effect prevent recurrence of EVF. NS ↑ stability of the ankle and clearance of the toes	No drop foot No planovalgus in adults REC Claw toes = 8/39 (on activity of FDB or on fixed deformity)
Morita *et al.* 1994 R, CS 7/16	FDL/ FHL-t **on 4th MT** (n=29, 100%) => Allow ADF by tenodesis effect or active action Alternative of TP-t (planovalgus risk)	CT-l (29/29; to obtain ADF-KE>10°) TP-l (5/29; if hindfoot varus when walking) FDB-r (3/29; if severe hammertoes)	Stroke (n=29) 58 [40-70] 29 [6-85]	EVF NS	NS FDL activation in SwP (in discussion, refers to Waters 1982)	NS Walk with: Orthosis 29/29 Cane outside 11/29 Cane inside 11/29 Cane under supervision 7/29	NS	38 m [24-60]	NS ↕ Orthoses 21/29 (72%) ↑ autonomy for 7 and stable for 22 ↑ Walking speed from 24.1 m/min to 29.8 m/min for 22	REC: EVF = 6 (21%) Claw toes = 11 (38%) (when no FDB-r) REC related to spasticity Complications: no
Gasq *et al.* 2013 R, CS 7/16	TP-t **on 3rd cuneiform** (n=20, 100%) => alternative of SPLATT (surgery not possible)	CT-l (20/20) (to obtain ADF 10°) FD-r (12/20) FHL-l (5/20)	Stroke (n=16) TBI (n=4) 51,7 [22-66] 102 [20-271]	EVF and calf muscle contracture - Activity of TA insufficient for SPLATT (deficient active voluntary contraction and no visible activation during walking) - Fibular muscles deficient in	Spasticity No sign of fibular overactivity during walking (visual) No sign of TA activity or insufficient to be responsible of hindfoot varus	NS Walking barefoot 0/20 with cane 16/20 Orthosis 18/20	NS	57,9 m [26-89]	No flat foot Valgus >10° for 6 (for 3 on the operated side, 1 bilateral, 2 on healthy side) Varus of 5° for 1 Voluntary Active contraction of TP for 2, the others had tenodesis effect ↑FAC for 3 and the others are stable (mostly 5 or 6) * Walking: barefoot 18/20 with cane 14/20 Orthosis 7/20 *	Claw toes REC=7 (when no FD-r) => tenotomy for 2 Calcaneus gait on overactivity of TP for 1 => repeated botulinum toxin No ≠ on X-Ray (medial arch, rearfoot) (healthy VS Paretic)

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									Statistically different OR *No statistical difference* (when mentioned)	
				testing and no activity while walking					NS	↓ plantar area (cavus foot) on operated side *
Giannotti *et al.* 2016 R, CS 7/16	FHL-t anterior (n=11;23%) EHL-t on **4th MT** (n=14; 30%)	With FHL-t CT-l (11/11) TP-l (2/11) FD-r (11/11) FDL- t to calcaneum (5/11) With EHL-t CT-l (14/14) FDB-r (14/14)	Stroke (n=47) 56 (15) 72 (60)	EVF NS	No spastic dystonia, no history of STN, no injection of BTI in the past 12 months NS	Laboratory gait analysis ADF-IC= -10 (8) ADF-StP= 4 (10) ADF-SwP = -8 (9) Walking >10 meters barefoot (study design)	NS	1 m	NS NS No ≠ in spatio-temporal parameters and speed except step width, double StP on healthy side ADF-IC= -1 (4) * ADF-StP= 11 (6) * ADF-SwP= 5 (7) * Linear correlation between preoperative and post-operative value *	NS
Sturbois-Nachef *et al.* 2018 R, CS 9/16	TP-t (n=13, 100%) **on TA or PB (if weakness of fibularis muscle) or on cuboid**	STN-GM (11/13) STN-UNS (11/13) STN-TP (4/13) CT-l (10/13) GM-apo (1/13) FHL-l (2 /13) FDL-r (4/13)	Stroke (n=5) TBI (n=3) Other (n=5) 42,7 [30-61] 65 [12-108]	No midfoot and hindfoot arthrodesis (exclusion criteria) Permanent hindfoot varus. weakness of the foot dorsiflexors	NS No activity of tibialis anterior during walking (Visual)	Permanent hindfoot varus during StP due to tibialis posterior muscle (No hindfoot varus during SwP due to to tibialis anterior muscle (exclusion criteria)) (Visual)	NS	5,5 y [1-9]	No flat foot, Pes cavus n=7 (53%) * Pronation n=2 (15%) Supination n=2 (15%) ADF-KE= 15 [0-30] ADF-KF= 23 [10-30] *MRC* ADF= 2.9 Active ADF = 11/13 (85%) AROM ADF-KE=-3.2 [-5 to 20] ADF-KF= 5.3 [5–20]	

Authors **Date** **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion)**	**Additional surgery** (n/total) (goal)	**Pathology** (total population) **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** **Dynamic muscle activation** (Visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up**	**RESULTS**	
									Clinical assessment **Autonomy, orthosis** **Kinetics, kinematics**	**Complications/ Recurrences (REC)**
									<u>Statistically different</u> OR *No statistical difference* (when mentioned)	
									Orthosis or OS =3/10 Activity of TA with ADF-SwP = 7/13 (54%) Range of ADF in SwP=5,3° [2-10°] Ground contact: sole: 9/ heel: 3/ forefoot: 1	
Giannotti *et al.* 2018 R, CS 8/16	EHL-t (on 4th MT) (n=1; 4%) Anterior FHL-t (n=5; 21%)	CT-l + FD-r (6/6)	Stroke (n=24) 55 (13) 60 (36)	EVF NS	No spastic dystonia, no history of STN, no BTI in the past 12 m NS	Laboratory gait analysis ADF-StP= 5 (9) ADF-SwP= -6 (15) ADF-IC= -11 (14) Walking >10 meters barefoot (study design)	NS	12 m	NS NS ADF-StP= 11 (9) * ADF-SwP= 3 (6) * ADF-IC= -4 (5) * ↑speed * (but still low, can be attributed in a lack of propulsion on weakness of plantar flexors)	No REC
Wagenaar & Louwerens, 2007 R, CS 8/16	TP-t (Hansen technique: split of TP and anterior transfer **on TA and PT or EDL**) (n= 5; 100%)	CT-l (5) Triple arthrodesis + EHL-t to LP + 1st IP arthrodesis (1) FDB-r + Broström procedure (1) DMMO (1)	Stroke (n=5) 38 [16-59] 96 [12-336]	EVF Flexible hindfoot varus ADF weak: foot drop (n= 3) TP ≥ 4+ (MRC)	TP hypertonia (n= 1) NS	Dynamic EVF (n=2) Lateral instability of the ankle (n=1) Orthosis 5/5	NS	45 m [11-72]	PROM: ADF>0° for 4 ADF <0° for 1 MRC: ADF = 4 to 4+ Orthosis 0/5 NS	Claw toes REC = 1 (on spasticity and no FDB-r preop) No valgus No flat feet 1 bad result = AROM <0° + drop foot + claw
Benedetti *et al.* 2011 R, CS	EHL-t (n= 2; 15%) FDL-t (n=1; 7%)	With EHL-t CT-l (2) FDB-r (1) TP-l (1)	Stroke (n=11) TBI (n=2) 51 [19 -74]	EVF hallux erectus: 1	NS NS	Laboratory gait analysis: ADF-IC = -15.6 (13.8) ADF-StP = -5.7 (14.2) ADF-SwP = -25,5 (14,5) Varus-SwP = 22.5 (17.6)	NS	4 m	NS FAC = 4,3 (0,6) * ↕ orthosis: 4 ↕ cane: 2	No REC

Authors **Date** **Type** **MINORS score**	**Type of transfer** (number; % of total; **Insertion)**	**Additional surgery** (n/total) (goal)	**Pathology** (total population**)** **Age** [range] or (SD), y **Delay** [range], m	**Passive ROM** [range] or (SD), deg **Motricity** strength in MRC scale, AROM in deg	**Muscle hypertonia** **Dynamic muscle activation** (Visual or EMG)	**Instrumental or visual kinematic gait analysis** **Autonomy**	**Botulinum toxin injection (BTI) or nerve block (NB)**	**Length of follow-up**	**RESULTS**	
									Clinical assessment **Autonomy, orthosis** **Kinetics, kinematics**	**Complications/ Recurrences (REC)**
								<u>Statistically different</u> OR *No statistical difference* (when mentioned)		
6/16		With FDL-t CT-l (1) FDB-r (1)	NS			FAC = 3,5 (0,8) All walkers (study design)			No ≠ in spatio-temporal parameters or speed ADF-IC= -10,3 (7) * ADF-StP= 4,4 (6,6) * ADF-SwP= -12 (7,6) * Varus-SwP = 16,7 (9) *	

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Conclusions et **perspectives**

La réalisation de ce travail a fait suite aux interrogations portées lors de l'évaluation préopératoire des patients dans le service des Explorations Fonctionnelles Physiologiques, lors des réunions de concertation pluridisciplinaires de Neuro-orthopédie et lors de la consultation médico-chirurgicale dans le service de MPR du CHU de Toulouse, en vue d'une chirurgie correctrice du pied équin varus. Les patients présentant un pied équin varus séquellaire d'une atteinte neurologique centrale et en demande de solution chirurgicale bénéficient d'une évaluation préopératoire complète comportant une évaluation clinique standardisée et une analyse quantifiée de la marche. Elle est souvent complétée par la réalisation de blocs moteurs nerveux sélectifs évaluant la réductibilité des déformations et l'impact fonctionnel d'une réduction de l'hypertonie. L'objectif de l'évaluation est de permettre de cibler les acteurs de la déformation et les attentes du patient. Les patients sont orientés vers la consultation médico-chirurgicale où sont considérés la déformation du pied mais aussi l'état général du patient. Cette consultation permet de déterminer si leurs attentes sont en adéquation avec les solutions chirurgicales proposées, et de proposer un plan chirurgical contractualisé avec les objectifs du patient. Les réunions de concertation pluridisciplinaires permettent de confronter les avis et de prendre des décisions collégiales pour les dossiers complexes. En l'absence de recommandations et d'arbre décisionnel standardisé, les décisions de prise en charge sont basées sur l'expérience personnelle et institutionnelle.

Afin d'étayer nos décisions, nous avons réalisé un recueil systématique des indications préopératoires d'une chirurgie correctrice d'un pied équin varus chez les patients cérébrolésés au travers d'une revue de la littérature. Cette dernière nous a permis de constater des limitations majeures. La qualité des études selon les critères MINORS était médiocre, le score faible lors de la cotation provenant souvent de l'absence de caractère prospectif des études et de l'absence de critères de jugement objectifs instrumentaux. L'utilisation de critères subjectifs ou cliniques n'a pas pu être compensé par la mise en place d'une évaluation en insu dans le cas des études chirurgicales. Le caractère rétrospectif, l'absence d'examen standardisé ou d'analyses instrumentales ont limité l'informativité des données collectées . Enfin il existait une nette séparation entre les pratiques neurochirurgicales et orthopédiques, la combinaison des deux étant exceptionnelle.

La motivation chirurgicale première était le positionnement plantigrade du pied en vue d'une amélioration fonctionnelle des patients. Cette dernière a été relevée pour la plupart des études par le sevrage des orthèses et aides techniques et souvent les échelles d'autonomie comme la *Functional Ambulation Classification*.

Partant du même objectif fonctionnel et ayant comme objectif commun de maitriser l'équin et/ou le varus, les pratiques chirurgicales divergeaient. Concernant l'équin, sa correction relevait de neurotomies sélectives des branches du nerf tibial (généralement du soléaire et des gastrocnémiens) dans le cas d'un muscle hypertonique sans part de rétraction. A défaut d'éléments cliniques plus précis, l'indication d'un allongement du triceps sural était posée en présence d'une rétraction, l'association à une spasticité n'étant pas abordée.

Une bonne gestion des muscles de la loge postérieure permet d'assurer un appui plantigrade, cependant il ne s'agit pas du seul facteur garantissant la diminution de l'équin en phase oscillante qui nécessite également une fonction conservée des antagonistes ou à défaut l'utilisation d'une orthèse. Lors des études concernant les neurotomies, même si une amélioration de la flexion dorsale en phase oscillante était notifiée, certaines études notaient assez peu d'amélioration. Ceci peut s'expliquer par une meilleure expression des antagonistes après diminution de l'hypertonie du triceps sural mais restant insuffisante pour assurer un relevé de pied physiologique. Des auteurs ont déjà étudié le lien entre les paramètres cinématiques pré et post opératoires, mais aucune étude statistique n'a été réalisée reliant l'état moteur préopératoire des fléchisseurs dorsaux et leur expression après neurotomie ou allongement. En l'absence d'éléments prédictifs, une alternative pertinente consiste à réaliser des chirurgies en deux temps, en gérant d'abord la loge postérieure, puis en gérant secondairement la réalisation d'une réanimation de la flexion dorsale de cheville si elle est nécessaire.

Concernant le varus, le transfert tendineux est le choix thérapeutique privilégié des chirurgiens orthopédistes pour obtenir une position plantigrade plus qu'un éventuel allongement du tibial postérieur ou un geste ostéo-articulaire. A l'inverse, devant un varus les neurotomies visent systématiquement le tibial postérieur sans qu'il n'y ait de transfert. Comment expliquer une telle différence si ce n'est par les pratiques chirurgicales intrinsèques à chaque spécialité ? Il

est présomptueux d'attribuer une déformation à un unique muscle et surtout de généraliser son implication chez tous les patients. Les deux méthodes ont montré des résultats probants lorsque le positionnement plantigrade était obtenu, que ce soit par l'application d'une force de traction en éversion ou par la diminution d'un déséquilibre entre inverseur hypertonique et releveurs et éverseurs parétiques. Le varus est un terme commun dans les études et une désignation en inversion ou supination serait plus précise. Cette distinction d'ailleurs a rarement été faite chez les patients spastiques en l'absence d'analyse dynamique de la marche dans le plan frontal, les analyse cinématiques réalisées en pratique courante ne permettant pas la mesure de ce paramètre. Le deuxième point soulevé a été le choix du tendon transféré. Le choix privilégié concernait le tibial antérieur, probablement en raison de la relative facilité de la technique chirurgicale de transfert. Par ailleurs, le varus ou la supination de l'avant-pied lui ont souvent été attribués. Or lorsque l'articulation tibio-talienne est en flexion plantaire, elle provoque biomécaniquement un varus calcanéen et une supination de l'avant-pied. Ce mouvement naturel du couple de torsion a peut-être été associé à tort à la seule action du tibial antérieur, ce muscle étant avant tout un fléchisseur dorsal et son action varisante en présence d'un équin n'étant que la conséquence de la modification de son point d'application. Le choix d'un transfert autre que le tibial antérieur renforce cette hypothèse et va dans le sens d'une implication des autres muscles dans la déformation en varus.

De manière générale, deux approches semblent se dégager. La première consiste à choisir les gestes chirurgicaux de manière très analytique en fonction de la physiopathologie précise de la déformation, l'idée sous-jacente étant de proposer une approche très personnalisée pour réaliser un geste minimal, utiliser les muscles impliqués dans la déformation et limiter le risque de récidive. Dans cette approche, la réalisation de chirurgies en deux temps, par exemple affaiblissement de la loge postérieure dans un premier temps, et réanimation de la dorsiflexion dans un second temps, permet souvent de mieux indiquer le second opératoire et parfois de s'en passer. La seconde approche est plus globale et consiste à choisir une technique chirurgicale plus standardisée et parfois détachée de la physiopathologie de la déformation avec l'objectif minimal de corriger l'équin et le varus pour restaurer un appui plantigrade. Par exemple, la réalisation d'un hémi-transfert du tibial antérieur ou d'un transfert du tibial postérieur chez un même patient aura pour effet dans les deux cas d'améliorer l'appui du patient. Au final, l'analyse de la littérature montre que les deux approches, analytique et globale, sont utilisées, avec dans les deux cas des améliorations fonctionnelles relevées. Il y a cependant plusieurs

éléments qui ne permettent pas de positionner ces deux approches au même niveau : manque d'éléments cliniques dans de nombreuses études ne permettant pas de connaitre la physiopathologie de la déformation et donc d'expliquer les échecs ou les récidives, évaluations très partielles et à court terme des résultats de la chirurgie ne permettant pas d'identifier les gênes résiduelles ressenties par les patients à moyen et long terme.

En pratique, une combinaison des deux approches parait être la plus judicieuse, afin de proposer une chirurgie la plus minimale possible mais avec le moins de risque de récidive et la plus forte probabilité d'amélioration fonctionnelle. L'évaluation pré- et post-chirurgical est une des clés dans cette démarche, de même que le fait d'avoir des chirurgiens maitrisant l'ensemble des techniques.

Enfin, un certain nombre de questions restent en suspens suite à notre revue de littérature, et de futurs travaux pourraient permettre d'y répondre :
- quelle est la participation respective des différents chefs musculaires du triceps dans la déformation, plutôt sur un mode spastique pour le soléaire et sur le versant rétractile pour les gastrocnémiens ?
- quelle est l'implication d'un affaiblissement trop important du triceps sural, que ce soit par le degré de section de la neurotomie ou pas le type d'allongement pratiqué, dans la réponse fonctionnelle de la chirurgie ?
- quelles sont les modalités (hypertonie ou modification structurelle) de récurrence de la déformation et ses facteurs favorisants (absence de fonction antagoniste ou hypertonie d'autres muscles fléchisseurs plantaires non traitée par exemple) ?
- quel est l'impact de facteurs tels que la présence d'un syndrome de l'hémisphère mineur ou de troubles proprioceptifs sévères dans la gestion des indications chirurgicales ?

A défaut de pouvoir réaliser aisément des études comparatives en chirurgie, une analyse de cohorte avec un examen clinique standardisé pré et post-opératoire associé à une évaluation multimodale de l'efficacité de la chirurgie permettrait de répondre à de nombreuses questions. Nous proposons donc le recueil systématique de données cliniques et paracliniques afin de permettre la comparaison des populations opérées en préopératoires et post-opératoires. Une autre perspective serait de proposer un arbre décisionnel de prise en charge où les points

consensuels de prise en charge seraient validés, et les points non consensuels pourraient faire l'objet d'études prospectives comparatives.

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Quels sont les critères cliniques et instrumentaux guidant le choix d'une chirurgie correctrice d'un pied équin-varus chez les adultes cérébrolésés ? Une revue systématique de la littérature.

RESUME EN FRANÇAIS :

Objectif.

Rapporter les données préopératoires orientant le choix des techniques chirurgicales dans la prise en charge du pied équin-varus (PEV) chez le patient cérébrolésé.

Méthode.

La méthodologie PRISMA a été respectée. Toutes les études notifiant une chirurgie du PEV du cérébrolésé en langue anglaise ou française et sans limitation de dates ont été incluses. La stratégie de recherche a concerné quatre bases de données (PUBMED, MEDLINE, COCHRANE, PEDRO). La qualité des études a été évaluée avec le score MINORS.

Résultats.

60 études (n= 2291 patients) ont été analysées, et concernaient des neurotomies (n=523), des allongements isolés de la loge postérieure de jambe (n=437), des transferts antérieurs du tibial antérieur (n=888), du long fléchisseur des orteils ou de l'hallux (n=249), du long extenseur de l'hallux (n=102), du tibial postérieur (n=41) et du long fibulaire (n=41). Une étude concernait spécifiquement la réalisation d'arthrodèses (n=10).
Les neurotomies étaient réalisées en cas d'équin spastique, non rétractés dans 87% des cas.
La motricité des releveurs de pied n'était évaluée que dans 70% et 27% des études concernant les neurotomies et les allongements isolés, respectivement, et notifiaient un testing supérieur à 2 en MRC pour 50 à 75% des études ainsi qu'une contraction sélective ou syncinétique pour 77% des patients.
Lors des transferts tendineux antérieurs, la motricité était relevée dans 20% à 46% des études, et la présence d'une activation musculaire à la marche dans 46 à 56% des études. Même si la présence d'une contraction volontaire favorisait un meilleur résultat, c'était la correction d'un varus qui justifiait le transfert du tibial antérieur dans 60% des études contre 30 % pour les autres transferts, ces derniers étant justifiés par leur hyperactivité musculaire ou leur possibilité de contraction volontaire.

Conclusions.

Cette revue souligne l'hétérogénéité des approches chirurgicales dans la prise en charge du PEV, et a permis de proposer une évaluation standardisée permettant d'adapter le choix des techniques à chaque patient

TITRE EN ANGLAIS : **Which clinical and instrumental criteria to guide the choice of surgical correction of equino-varus foot in brain-damaged adults? A systematic scoping review.**

DISCIPLINE ADMINISTRATIVE : Médecine spécialisée clinique

MOTS-CLÉS : Foot Deformities, Acquired; Hemiplegia; Orthopedic Procedures; Tenotomy; Tendon Transfer; Neurosurgical Procedures

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