

ORIGINAL ARTICLE

Report on 250 consecutive toe to finger transplants. Indications, results, failures, and new applications

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KEYWORDS

Amputation;
Microsurgery;
Toe-to-han

Abstract

Purpose: Toe-to-hand transfers are an essential part of hand rehabilitation after loss of a finger. Despite this, the likelihood of failure and the hypothetical morbidity in the donor area, made this procedure not very popular among surgeons. The purpose of this paper is to present our clinical experience, highlighting the pitfalls and the new indications.

Material and methods: Between February 1995-January 2010 we performed 250 toe-to-hand transfers for finger amputations. In metacarpal hands (23 cases) we transferred the hallux from one foot and the 2nd and 3rd from the other, to achieve a three-fingered (tripod) grasp. The rest of the patients had multi-digit, simple or partial amputations. In 69 the thumb was reconstructed and the rest of transfers were for finger reconstructions.

Results: Re-operation rate due to acute ischaemia was 16% (10% intraoperative) and the overall success rate was 98.8% (3 failures). There was no partial necrosis in any case. Regarding the donor side, one patient was operated on due to a painful neuroma; the rest did not have complaints in the donor area.

Conclusions: In our experience toe-to hand transfers are a safe and reliable method to rehabilitate severe hand injuries. Donor site morbidity is directly related to the number of toes harvested, and is well-tolerated by the patients, especially in severe injuries.

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PALABRAS CLAVE

Amputación;
Microcirugía;
Dedo del pie a la mano

Informe sobre el trasplante de 250 dedos del pie a la mano consecutivos. Indicaciones, resultados, fracasos y nuevas aplicaciones

Resumen

Propósito: Las transferencias de dedos del pie constituyen un arma fundamental en la rehabilitación de las lesiones de mano. Sin embargo, no gozan de mucha popularidad

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dada la posibilidad de fracaso y por las hipotéticas secuelas en la zona donante. Presentamos nuestra experiencia clínica, haciendo especial hincapié en las complicaciones y las nuevas aplicaciones.

Material y métodos: En el periodo febrero de 1995 - enero de 2010 hemos realizado 250 transferencias de dedos del pie para amputaciones de todos o parte de los dedos. En las amputaciones de todos los dedos (23 casos) se trasplantaron el hallux de un pie y el 2.º y 3.º dedos del pie contralateral para lograr una pinza trípode. El resto de los casos corresponden a amputaciones multidigitales, simples o parciales de dedos, siendo 69 casos pulgares y el resto, dedos trifalángicos.

Resultados: La tasa de reintervención por isquemia aguda fue del 16% (10% intraoperatoria), con una supervivencia final del 98,8% (3 fracasos) tras la revisión quirúrgica. No hubo ninguna necrosis parcial. Respecto a la zona donante, un paciente fue intervenido por presentar un neuroma; el resto no refirió ningún tipo de molestias a la marcha, en el seguimiento a largo plazo.

Conclusiones: En nuestra experiencia, las transferencias de dedos del pie son un método seguro en la reconstrucción de lesiones graves de la mano. La secuela del pie es proporcional a la cantidad de dedos que se tomen, y es bien aceptada por el paciente, en especial en las graves lesiones.

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Introduction

Toe transfers have been a routine practice for more than 40 years.¹ Although initially its use was limited to the thumb, it came to be more widely used as survival rates improved. So much so that, nowadays, these transfers are indicated in both reconstruction of severe injuries (for example, multi-digit amputations) and in more minor injuries (for example, partial thumb amputations) where the treatment objective is, essentially, *restitutio ad integrum*.²

Our purpose is to present an update on the indications, results, and donor site sequelae based on our experience with 250 transfers.

Materials and methods

From February 1995 to January 2010, we performed 250 toe-to-hand transfers. The first author was involved in all cases, without exception.

Although there were paediatric and elderly patients in our series, our case load consisted of labourers, primarily, and the mean age for our series was 37.6 years (range 2-64). Certain conditions such as age, smoking, hypercoagulable states, and previous trauma in the donor site area are unfavourable factors, but these do not contraindicate transplant as long as it is thought that the patient may benefit from the surgery. It is contraindicated, however, if the patient is in poor general condition or has a severe, arteritis obliterans-type of arteriopathy.

Forty-nine patients received 2 toes, and 27 patients received 3 toes. In 38 cases, it was necessary to combine the toe-to-hand transfers with another type of microsurgical tissue transfer, either during the same procedure or prior to it, because of coverage problems.

Of the 250 cases, 148 transfers were done early (less than 1 week) (fig. 1), and 43 were done prior to 1 month. The remaining 59 were performed late (range: 5 weeks to 32 years).

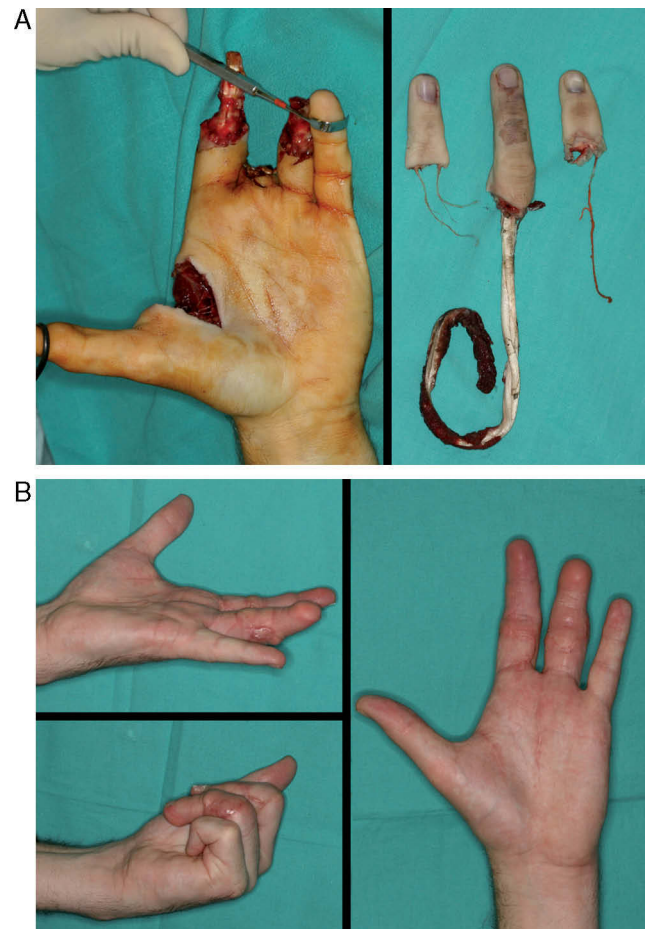


Figure 1 A) 28-year-old patient with multi-digit amputation due to avulsion and injury at various levels, which made it impossible to reimplant 2 of the fingers. A heterotopic reimplantation of the 3rd to the 2nd position was performed on an emergency basis. One week later, patient underwent an aesthetic amputation of the third ray and the transfer of a 2nd toe to the 4th position. B) Results at 3 months.

The elevation technique has already been described,³⁻⁵ but we would like to stress the importance of skeletonizing the arteries and veins to reduce the amount of fat and the volume of the pedicle transferred to the hand. This precludes the need for skin grafts or flaps as a means of fitting the excess tissue onto the hand, and because better aesthetic results are achieved in a single procedure, it also obviates the need of a second surgery for remodelling. With experience, our preference for donor vessels has changed from the dorsal artery of the foot or the first dorsal intermetatarsal artery and the saphenous vein, which was our initial practice, to the tibial and/or fibular digital artery and a dorsal subcutaneous vein from the commissure of the finger, currently. This has enabled us to shorten the total surgery time to about 3 hours, currently, and to minimize foot morbidity. There is a downside to it in that the vessels for the microsurgery are of smaller calibre.

While the toe is being adapted to the hand, another surgical team closes the resulting defect in the donor site area. They use different techniques for this depending on the amount of tissue harvested from the foot. Defects resulting from the transfer of soft tissue from a toe (hemipulp or neurocutaneous⁶) are reconstructed using neurovascular island flaps or skin grafts. On the other hand, if a phalanx or a joint has been harvested, we preserve the toe by doing an arthroplasty or creating a syndactyly.^{7,8}

If a 2nd toe has been harvested, an aesthetic amputation of the ray is done, with resection of the metatarsal and closure of the space between the 1st and 3rd metatarsal with 2 Kirschner wires for 5 weeks. Transfers of the big toe are reconstructed through transfer of the 2nd toe to the 1st toe position.⁹ In the event of a combined, tandem-type transfer of the 2nd and 3rd toes, we try to preserve the metatarsophalangeal joints to prevent difficulties with ambulation.¹⁰ We recommend to patients that they avoid weight-bearing for 6 weeks. Following surgery, patients remained in the hospital for a mean period of 6 days on a continuous heparin infusion, and they were monitored with an acoustic Doppler sensor.

Results

In 84% of the cases, immediate revascularisation of the toes was achieved upon removing the vascular clamps, with no further complications. In 16% of the cases, the anastomosis had to be revised: in the same surgical procedure, after removing the clamps (10%) or in a separate procedure after patient was returned to the floor (6%). On 3 occasions, complete necrosis occurred (overall survival: 98.8%) despite all attempts to resolve it (reanastomosis, interposition grafts, and the like). There were no cases of partial necrosis.

Regarding morbidity of the donor site area, we had 2 cases of medium-term discomfort with walking. One patient, who had undergone transfer of a 2nd toe and a contralateral big toe, reported discomfort with walking due to a neuroma in the stump of a collateral nerve, which was resolved by transposing it. Another patient, on whom a tandem flap had been transferred (2nd and 3rd toes) for a metacarpal hand reconstruction, reported pain in one of his feet when walking; this persisted for 2 years, despite orthotic treatment. The discomfort disappeared when the

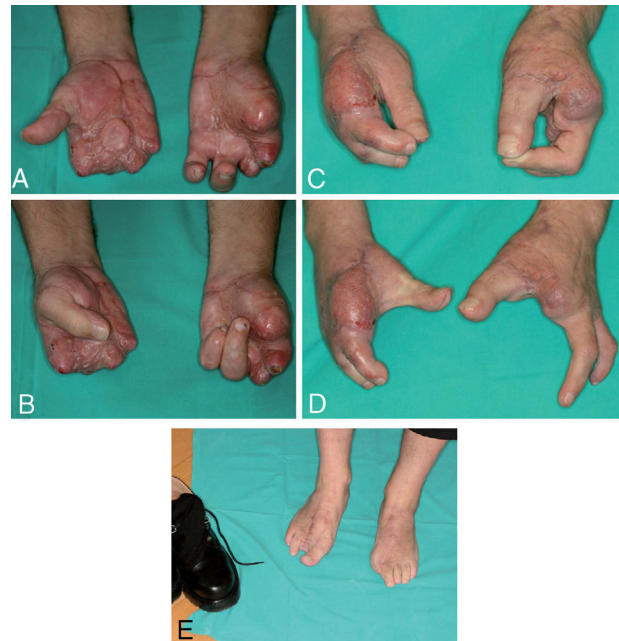


Figure 2 A-B) Bilateral metacarpal hand referred 5 months after injury. C-D) On the left hand, the big toe was transplanted to the thumb position, and the stumps of the 2nd and 3rd metacarpals were resected to provide a good commissure. The right hand was reconstructed by transferring a microvascular lateral thigh flap and a tandem flap of the 2nd and 3rd toes in the same surgical procedure. E) Case 2 donor site area 4 years after surgery. The patient reports walking at least 10 km every day. Note that patient wears regular shoes.

patient was integrated into a new job, and he has required no further treatment.

We have had some problems with primary wound healing in the donor site area, above all in those cases where there was an associated fasciocutaneous flap. These cases closed by second intention.

One patient with hypercoagulability due to protein S deficiency developed a deep vein thrombosis in the donor leg, 10 days after the surgery when he was already at home and despite low-molecular-weight heparin therapy. After warfarin therapy was instituted, progress was favourable both for the patient and for the transferred first toe.

Discussion

The toes enable hand function to be improved in proportion to the existing deficit. In cases of multi-digit amputations or metacarpal hands, they are used to achieve a simple or tripod grip,^{4,10,11} while in less serious cases, they contribute to a practically total anatomical and functional recovery.^{2,12}

Donor site area

Both the aesthetic and functional outcome in the foot depends upon the defect to be reconstructed. Minor lesions are reconstructed almost anatomically, with minimal sequelae in the foot, while in the case of multi-digit



Figure 3 Outcome for the donor site area of a first toe used in thumb reconstruction, with and without transposition of the toe.

amputations where several toes are harvested, there are more sequelae in the donor site area (fig. 2). When it is a metacarpal hand,¹³ for example, the big toe is harvested from one foot and a flap combining the 2nd and 3rd toes from the contralateral foot.¹⁴ In terms of morbidity in the donor site area, various studies have shown that gait is not impaired if the base of the proximal phalanx of the big toe is left or if no more than 2 toes are harvested.^{15,16}

Our results agree with those of other series^{3,17-20} in which problems with ambulation are practically non-existent. In reviewing our results with transfers of the 2nd and 3rd toes combined—one of the most serious assaults on the donor site area to which the foot is subjected—not one patient reported any functional sequelae with regard to ambulation.⁴ Of the remaining patients (simple toe transfer), 1 patient required another surgery to transpose a neuroma, and another patient reported discomfort that improved with using orthotics, pain after walking several kilometres, despite non-weight-bearing insoles, metatarsal bars, etc.

Resection of the big toe resulted in a very noticeable aesthetic flaw if the stump was simply closed. To mitigate this defect, we transposed the second toe to the first position and increased its volume using a tibial cutaneous interposition flap (fig. 3).⁹ We followed a total of 17 patients over a minimum of 2 years. Evaluation of functional sequelae in the foot using a Visual Analogue Scale (VAS) (no limitation, no pain=0..incapacitating limitation, intolerable pain=10) resulted in a mean of 2.4, and for aesthetic sequelae (normal=0...severe deformity=10), a mean of 3.6. Evaluation of sequelae in the foot using the AOFAS scale resulted in a mean of 89.4.²¹

Re-operations and failures

One of the primary reasons for discouragement among surgeons who do this type of procedure is the risk of microvascular complications. After dissection and with the toe still connected to its vessels in the foot, it is not

uncommon for it to take a few minutes for the toe to be reperfused, especially when the donor vessels are the digital arteries. This spasm normally subsides with the passage of time and the application of local heat and/or a topical spasmolytic agent. Much more rarely, the toe remains totally ischaemic on the foot following release of the ischaemia cuff and never becomes reperfused, despite the passage of time and microsurgical exploration (revision of possible artery lesions, adventicectomy, etc.). In our experience, this type of complication (12 cases) was due to hypertrophy of the digital artery tunica media, which almost occluded it (10 cases), or embolism secondary to arteriosclerosis (2 cases).²² Our initial hypothesis to explain these ischaemic episodes in the foot pointed toward arterial hypertension as the causal mechanism because they occurred in patients who were over 50 years of age. This suspicion was reinforced by the anatomical pathology findings of arterial occlusion due to hypertrophy of the tunica media. However, we have recently seen a similar picture in a group of young, athletic patients (a marathon runner, among others) who do not have arterial hypertension. At the present time, we are looking into the hypothesis that repeated trauma may be another factor in the appearance of this problem and that hypertrophy of the tunica media could be of multi-factorial origin. This complication may be the cause of inexplicable failures with this technique and, worse, cannot be predicted before the foot is dissected. The way to resolve the problem is outside the scope of this general article. Suffice it to say, however, that this is a major challenge for a group skilled in microsurgery and that it forces us to do bypasses and/or anastomoses with arteries of less than 0.3 mm (fig. 4) because, for some unknown reason, the more distal vessels are usually healthy. In our experience with this complication (12 cases), we were able to resolve 11 of them through complex bypasses, and/or they required anastomosis of vessels of up to 0.5 mm. The other case was one of the failures in the series.

With regard to the failures (3/250), 1 of them was due to hypoperfusion in the foot in a patient with severe arteriosclerosis (mentioned above). The second failure was

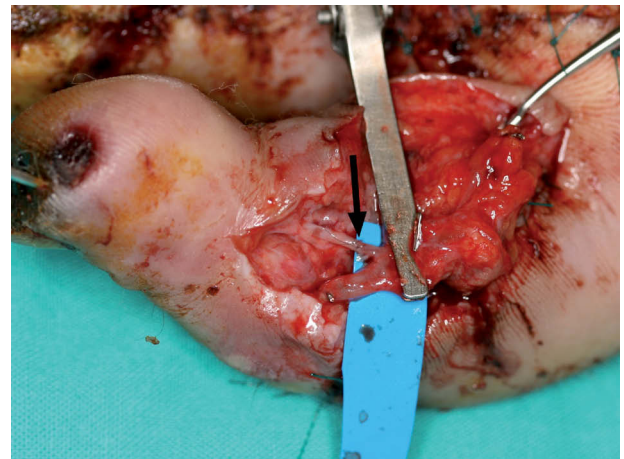


Figure 4 Rescue of an ischaemic toe due to hypertrophy of the tunica media in a young patient. The toe was revascularised via a bypass to the fibular digital artery at the DIP crease of the 2nd toe (artery diameter approximately 0.3 mm).

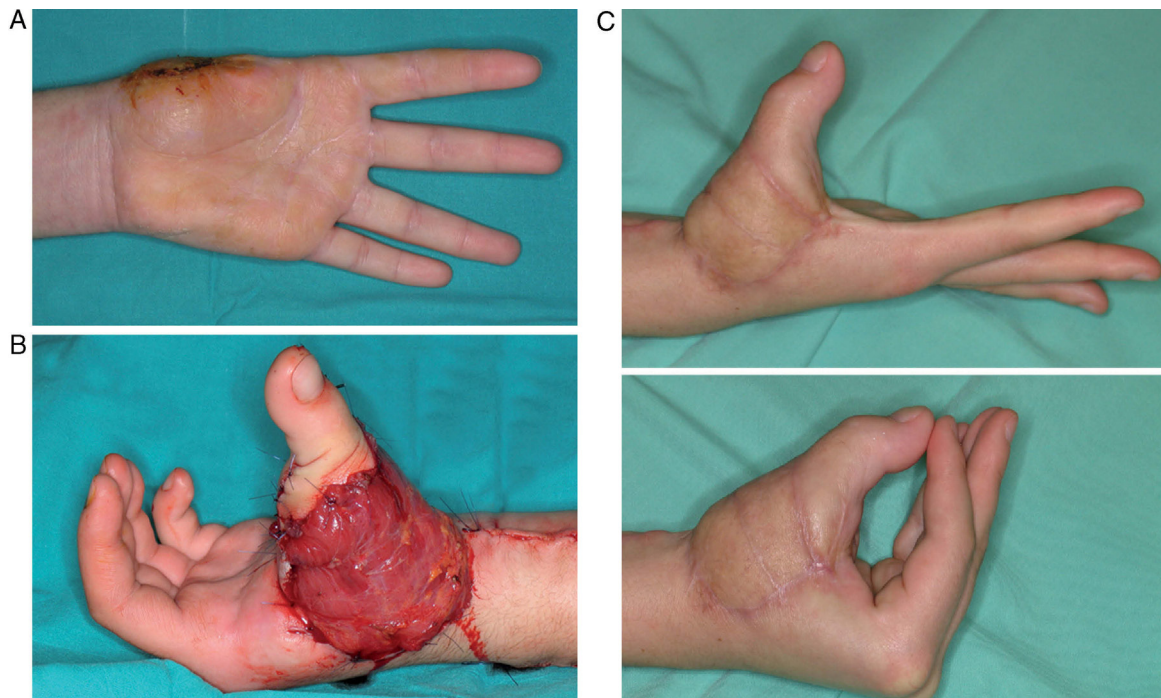


Figure 5 A) Amputation of thumb at the level of the trapezio-metacarpal-phalangeal joint. B) Simultaneous transfer of a toe plus a microvascular gracilis muscle flap for coverage. C) Final result.

related to a Buerger vasculopathy, and the third was due to poor post-operative management that made revision and early rescue impossible.

Because of our experience, enabling us to shorten the surgery time and achieve greater reliability with this type of transfer, we have expanded the indications along 2 lines: in complex reconstructions and in “minor” lesions. In multi-

digit amputations, where there is typically a loss of associated soft tissue, we perform other microsurgical tissue transfers along with the toe transfer in a single surgical procedure. This reduces rehabilitation time for the hand and precludes other surgical procedures on healed areas (fig. 5).

The other line of intervention has been the so-called mini-transfers: transfers of vascularised phalanges,

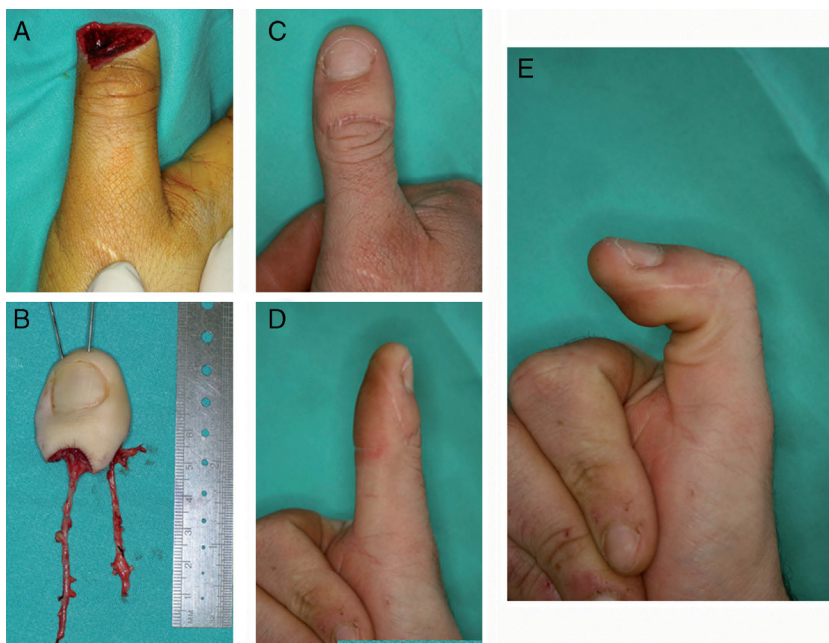


Figure 6 A) Amputation of distal thumb at the interphalangeal joint. B) Big toe modified per the Wei technique (trimmed toe). C-E) Result.

vascularised digital nerves, and distal toe reconstructions. Generally speaking, these mini-transfers are technically demanding in that they require reduction of the bone, adaptation of the soft tissues, and anastomoses with vessels of 0.5-0.8 mm. On the other hand, morbidity in the foot is minimal, and these mini-transfers enable hand anatomy and function to be almost fully recovered (fig. 6).

Conclusions

The toes enable function to be improved in a traumatised hand. The objectives will vary depending on the severity of the injury (tripod grip or anatomical reconstruction), and morbidity in the donor site area will vary depending on the amount of tissue harvested from the foot. This surgical procedure does not involve any drawbacks in terms of ambulation.

Evidence level

Evidence level IV.

Protection of human and animal subjects

The authors declare that no experiments were performed on humans or animals for this investigation.

Confidentiality of data

The authors will declare that they have followed the protocols of their work centre on the publication of patient data and that all the patients included in the study have received sufficient information and have given their informed consent in writing to participate in that study.

Right to privacy and informed consent

The authors declare that no patient data appears in this article.

Conflict of interest

The authors have no conflict of interest to declare.

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