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Toe-to-hand transfer: Evolving Indications and Relevant Outcomes

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Abstract

In the late 19th century, the first toe to hand transfer was performed in Vienna, Switzerland as a staged procedure by Nicolandi.(1) Since that time, the advent of microsurgery has revolutionized toe to hand transfers. In 1966, Buncke performed the first microvascular toe to thumb transfer in a rhesus monkey.(2) The first toe to thumb transfer using microsurgical techniques in humans was performed by Cobbett in 1969, followed shortly thereafter by the first transfer of a second toe to the thumb position.(3,4) Today, due to expanding microsurgical techniques and surgeon innovation, the indications and techniques for toe-to-hand transfer procedures continue to evolve and now encompass patients with a variety of acquired and congenital hand defects.(5)

Keywords

digital amputation; thumb reconstruction

Evolving indications

Traumatic thumb amputations are devastating injuries causing loss of pinch and grasp function.(6) An ideal thumb reconstruction should create a digit that is similar in appearance to the contralateral thumb, is sensate and functional, and is associated with minimal donor site morbidity.(7) Classically, patients who have suffered traumatic loss with an intact metacarpophalangeal joint are ideal candidates for toe-to-thumb transfer, and pollicization is reserved for patients with more proximal injuries and without a stable CMC joint.(8) Recently, compound flap techniques that include a great toe wrap-around with vascularized second-toe joint transfer have been successful in patients with more proximal injuries, and the indications and techniques for toe-to-hand transfer procedures continue to evolve (Table 1). (5,9)

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In addition to thumb reconstruction, toe-transfer techniques have been applied to patients who have suffered single and multiple digit amputations, finger amputations distal to the sublimis tendon insertion, and complete hand amputations.(10-13) Particularly for patients in whom meticulous digital function or form must be replaced, the distal pulp, nail complex, and distal interphalangeal joint can each be replaced with elements harvested from the first or second toe.(14-17)

Finally, toe-to-hand transfer has been successfully performed in children for a number of conditions. Congenital thumb absence, constriction ring syndrome, and symbrachydactyly are now potential indications for toe-hand transfer in order to restore sensate pinch.(18-19) Although early attempts were met with concern for epiphyseal disruption and premature closure, more recent series indicate that toes transferred to the hand in children can reach up to 100% length of the contralateral toe and with normal growth.(20)

Timing of toe transfer

Although the majority of toe transfer procedures are performed in a delayed manner, immediate toe transfer procedures in patients suffering traumatic amputation and crush injuries is gaining acceptance, and can be performed with similar rates of success.(21, 22) Yim et al. compared 26 primary and 96 secondary toe to hand transplantation procedures and did not identify any differences in survival or immediate and late complications.(23) Although long-term function has not been compared by timing of reconstruction, immediate toe transfer has the potential to minimize the number of hospitalizations required for restoration of hand function as well as allowing for earlier return to work.

Functional outcomes

Compared with patients who do not undergo thumb reconstruction, toe transfer restores objective and subjective hand functioning.(6) For example, a recent review of 49 patients undergoing toe-transfer with three-year follow-up demonstrates that the majority of patients can accomplish fine motor tasks with ease. Pinch strength can be restored up to 75% of the contralateral hand.(24) Grip strength can be restored from approximately 70% of the contralateral hand when performing an immediate second to transfer, and up to 90% with osteo-onychocutaneous techniques.(25) Static two-point discrimination can be achieved to 10mm, and later sensory reorganization allows for ongoing improvements in perception of touch, and interpretation of signals from the transferred digit. However, a recent systematic review of the literature failed to identify any differences in outcomes by technique, largely due to the heterogeneity of current data, which is largely limited to smaller, single center studies and case series.(26)

Aesthestic outcomes

Although function can easily be restored, aesthetic appearance is more difficult to achieve. Transfer of the big toe results in excess bulk and contour irregularity, whereas the smaller, bulbous tip of the second toe frequently has a hook appearance and a smaller nail that is difficult to mimic the contralateral thumb and digits (Table 2). However, secondary procedures have evolved to address these concerns.(27) For example, for patients

undergoing big toe transfer, the fibular tubercle including bone and soft tissue can be debulked in a second procedure, the so called trimmed toe technique.(28) For patients undergoing second toe transfer, radial or ulnar pulp-plasty techniques, tightening the extensor mechanism, and interphalangeal joint fusion can prevent a claw appearance.(29, 30)

Psychosocial outcomes

Not surprisingly, digital and thumb amputations have profound impact on quality of life, psychosocial functioning, and the ability of the patient to return to work.(31) Although patients make significant strides with respect to function and appearance, their return to pre-injury function is less clear. Strengthening and vocational training usually are deferred for the initial 2 months following transfer, yet up to 68% of patients who underwent toe-to-thumb transfer ultimately return to their pre-injury profession.(24) Furthermore, toe-thumb transfer patients report significantly higher vocational function scores compared with thumb amputees.(6) Although patient satisfaction with the donor and recipient site is often reported as high, few studies have used standardized measures validated in this patient population to systematically evaluate outcomes. Therefore, longitudinal, comparative studies of patients undergoing toe-to-hand transfer can provide insight into how patients re-integrate into society, adjust psychosocially, and the influence of these procedures on health-related quality of life.

Conclusions and future directions

Although free toe transfer techniques continue to evolve, these procedures are lengthy, technically demanding, and result in unavoidable donor site morbidity. However, recent advances in tissue engineering may overcome some of these drawbacks, and may ultimately become a viable option for replacing traumatically or congenitally absent digits.(32) Bone and soft tissue engineering from bovine derivatives or inert substances have shown great promise in early studies, and may expand the population of patients who may be candidates for reconstructive procedures. (33-35) Ultimately, systematic evaluation of the outcomes of toe-to-hand transfer will better inform patients and surgeons facing the decision for thumb and digital reconstruction for traumatic and congenital loss.

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Table 1

Indications for toe to hand transfer.

Adults	Traumatic thumb amputation
	Traumatic digital amputation distal to the flexor digitorum superficialis insertion
	Multiple traumatic digital amputation
Children	Congenital thumb absence
	Constriction ring syndrome
	Transverse arrest
	Longitudinal deficiency
	Symbrachydactyly

Table 2

Advantages and disadvantages of to toe to hand transfer techniques

Technique	Advantages	Drawbacks
Great toe transfer	• Excellent thumb stability and interphlanageal (IP) joint motion	• Donor site aesthetics • Larger size and contour differences compared with the contralateral toe • Must preserve metatarsal head to prevent gait deficit
Second toe transfer	• Donor site less apparent • Can include the metatarsal joint without impeding function, and varying degrees of the metatarsal can be harvested for length	• Bulbous thumb tip and smaller nail • Claw deformity • Less stability and motion
Wrap-around toe transfer	• Better size and contour match with contralateral thumb • Ideal for patients with degloving injuries and intact skeletal elements, and distal amputations	• Requires conventional bone graft (ex. iliac crest) for support, which may resorb over time • IP joint cannot be reconstructed • Pulp instability
Trimmed great toe transfer	• Better size and contour match with contralateral thumb • Includes the IP joint	• Reduced IP motion