TOE TO HAND TRANSFER. GENERAL CONSIDERATIONS

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REZUMAT

Absenta uneia sau mai multor degete reprezinta leziunea cea mai frecventa in patologia membrului superior, de aceea se impune reconstructia in majoritatea cazurilor. Există câteva obiective absolut necesare in reconstructia unui deget: a) Mai puține proceduri chirurghice; b) Obținerea: - unei bune mobilități; - unei bune sensibilități; - forței; - unui rezultat cosmetice bun; c) Păstrarea potențialului de creștere. Unele din cele mai bune metode pentru obținerea acestor obiective pot să fie transferul digital de la picior la mâna. Lucrarea prezintă rățiunea acestei metode și tactica chirurgicală în experiența autorilor, precum și o tezere în revistă a literaturii de specialitate.

Cuvinte cheie: reconstrucție digitală microchirurgicală, transfer digital

ABSTRACT

The absence of one or more fingers represents one of the most frequent lesions in upper limb pathology; there's why the reconstruction is mandatory to be done in most of the cases. There are some imperative techniques in finger reconstruction: a) Less surgical procedures; b) The obtaining of: good mobility; good sensibility; strength; good cosmetic appearance; c) Preservation of growth potential. One of the best surgical methods in reaching these objectives seems to be the toe to hand transfer. The paper presents the rational and operative tactics considered by the authors and a review of the literature.

Key Words: microsurgical digital reconstruction, toe(s) transfer(s)

INTRODUCTION

The absence of one or more fingers considerable restricts the hand functionality. The main purpose of any technique of reconstruction has to be the reconstruction of the missing fingers with similar tissues in structure and function as close to the original as possible.

Until microsurgery was born in the 1960's, many methods of finger and especially thumb reconstruction were performed using: local tissue rearrangement (Huguet 1874, Gillies and Millard 1957, Matev 1970), index pollicisation (Guermonprez 1887, Gueullette, 1930), other finger pollicisation (Tanzer and Littler 1948), multi-staged reconstructions with remote tissues, or more complicated, but single-stage procedures of thumb replacement with an osteocutaneous pedicle radial forearm flap.1-8

None of these methods were able to accomplish all the demanding qualities of a finger. The development of microsurgery renewed the first attempt of Nicoladoni, who performed, in 1898, a two stage procedure by transferring a great toe after it was held attached to the hand as a pediele flap for tree weeks.9

Thus, with the procedures of Cobbett (1968) and Yang (1966) the toe-to-hand finger transplantation become the first and the best therapeutically option in finger reconstruction.10,11 Since then, various refinements of these methods have been described: partial toe transfer; wrap-around flap; nail and nail-bed transfer; joint transfer, trimmed toe transfer each of them with application in selected cases.12-18

This paper will demonstrate the advantages of such a reconstruction method and the main tactical and technical consideration, which may be taken into account for every surgeon who stands to do it.
TACTICAL CONSIDERATIONS

If the general status of the patient allows the effectuation of such a surgical procedure, there are some features, which must be taken into account:19

A. Indications;
B. Timing of reconstruction;
C. Status of the hand;
D. Status of the foot;
E. Which toe will be used;
F. Patient consent.

A. Indications
A lot of etiological conditions can generate the absence of one or more fingers in the hand:

Congenital deficiencies: the procedure can be done in both longitudinal defects (hypoplasia, isolated aplasia) and transverse defects (symbrachydactyly, constriction ring syndrome).20,21 But the better indication seems to be the amniotic band syndrome, in which the vessels are more constant and they have a larger caliber.22,23 Very important is to use those procedures, which allow the inclusion of a viable growth plate.

Traumatic amputations: these represent probably the most frequent indication. There are some things which must be taken into account:
- The mechanism of the previous injury (the avulsion can raise some problems concerning the reconstruction)
- If the healing was uneventful (the presence of an infection must be considered)
- The status of the stump vessels and nerves

Surgical amputations: these can be performed for a large number of tumors or for other pathological conditions (extensive hemangiomas, etc.). But, do not forget that first of all, the appropriate treatment of the tumor must be done.

Not any finger absence is mandatory to be reconstructed. (Fig. 1)

The absence of the thumb, of all long fingers or of all the fingers must be considered as an absolute indication, while the amputation of only one, two or three fingers, with the conservation of the prehensile function of the hand, has only a relative indication.

Concerning the age of the patient, the younger the patient is, the advisable the indication.

There are also some particular indications from aesthetical point of view, but in only few cases and for special reasons.

B. Timing of reconstruction
For congenital deficiencies, the procedure should be done over the age of one year but before 18 months, at this age the child being able to incorporate better his reconstructed finger.24,25

In traumatic amputations the reconstruction is better to be done as soon as possible, this attitude having a good psychological impact for the patient and allowing him a faster social and professional reinsertion.

There are some situations in which even an emergency reconstruction is mandatory to be performed, as in complex traumas with finger(s) amputation(s) and soft tissue defects.19,20,26,27 (Fig. 2)

In case of tumors, depending on their type, the reconstruction can be done both at the time of the amputation or later on.

C. Hand Status
It is very important:
- To have good skin (it must not be forgotten that in burned hands the superficial veins may be destroyed).
- The tendons not to be avulsed.
- The nerves to be very closed to the end of the stump.
- The vessels must not be closed to the end of the stump, the length of the transferred toe pedicle allowing the anastomose with the radial artery in the anatomical snuff-box).

Some special considerations have to be discussed concerning the functional status of the hand, too. It is very well known that for a good function of the hand it is sufficient to have a mobile segment and a fixed one. For a good function of the thumb, the single joint, which is necessary to be absolutely normal, is the trapezometacarpal joint.13 So, it would not be necessary to reconstruct a thumb having mobility in the metacarpophalangeal and/or in interphalangeal joints. This is important if a reconstruction by using

Figure 1. Indications of finger(s) reconstruction function of lesion type: a. absolute indications; b. relative indications.
The cosmetic appearance is not a very good one after harvesting the great toe or the digital block of 2nd and 3rd toes; no functional deficit and minimal cosmetic deficit will appear after harvesting the second toe. (Fig. 4)

The classical described wrap-around method (with iliac bone) is decided.

D. Foot Status

There are two main points, which must be discussed concerning the foot as donor site: foot function following toe(s) harvest and the vascular anatomy of the foot.

a. Functional implications

If the great toe is transferred, its metatarsal head and sesamoid bones have to be respected to better preserve balance and push-off. In some situations, if the metacarpophalangeal joint is to be reconstructed, it is possible to harvest also a small portion from the first metatarsal head without any functional impairment of the foot. (Fig. 3)

The cosmetic appearance is not a very good one after harvesting the great toe or the digital block of 2nd and 3rd toes; no functional deficit and minimal cosmetic deficit will appear after harvesting the second toe. (Fig. 4)
The choice depends on the finger which must be reconstructed, on the level of amputation and the number of amputated fingers and, of course, on the patient’s option.

Because the greater surface, the strength and the cosmetic appearance, the use of great toe in reconstruction of the thumb seems to be more appropriate.¹⁹,²⁶,³⁴,³⁵

By respecting the first metatarsal head there isn’t any functional impairment, but the cosmetic appearance of the donor site is not a very good one. Of course, depending on the patient’s option, the thumb can be reconstructed also by using the second toe, but with only satisfactory functional and cosmetic results of the hand.²,¹⁹,²⁶,²⁸ (Fig.6)

Some authors consider that an arteriography or vascular Doppler is well to be performed before surgery in order to know the type of vascular supply.

E. Which toe will be used?

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Concerning the veins there is a very well represented superficial dorsal network that provides a very good drainage.

Figure 5. Vascular anatomy of the foot. a-c. the first dorsal metatarsal artery (FDMA) coursing dorsally to the deep transverse metatarsal ligament (DTML); dorsal to the interosseous muscle (a), through it (b) or deep to it (c); d. the FDMA coursing deep to the DTML; e. absence of the FDMA

Figure 6. Second toe to thumb transfer. 5 years after a crush injury of the right hand in a 52 years old man (amputation of the thumb and little finger; forearm vicious scar; bony defect of the flexor tendons and cubital vasculonervous pedicle). a. preoperative aspect; b-c. six month after one stage complex reconstruction (scar excision, reconstruction of the 2nd, 3rd and 4th flexor tendons and coverage of the antebrachial skin defect by using a free flow through Chinese flap including vascularised tendons; reconstruction of the thumb by using a second toe transfer)

b. Vascular anatomy of the foot

The main arterial supply of the first two toes is assured by the dorsalis pedis artery through its first dorsal metatarsal branch. The last one generally has (in about 2/3 of cases) a course dorsally to the deep transverse metatarsal ligament and passing dorsal to the interosseous muscle, through it, or deep to it. In about 1/3 of the cases, the first metatarsal artery is present but very small, the arterial supply of the first two toes being assured by the first metatarsal artery which courses deep to the deep transverse metatarsal ligament and originates from either the dorsalis pedis artery or the deep plantar artery. In only few cases the first dorsal metatarsal artery can be absent, the blood supply coming from the first metatarsal artery originating from the plantar arterial arch. (Fig.5)
The second toe can be harvested from any of the feet, but, if the great toe is used, it is preferable to harvest the ipsilateral one because of the natural angle of 10-15 degrees lateral opened.

If a digital block of the second or third toes is used, the donor foot will be chosen function of which fingers are to be reconstructed, to preserve the length cascade of the fingers. In the reconstruction of long fingers, the use of a toe transfer is indicated only if more than two fingers are amputated or for cosmetic reasons.

The second toe from one or both feet can be used for reconstruction, in the last case as simultaneous or consecutive procedure; it is also possible to use a digital block of second and third toes, but only if the level of the amputation stump is proximally located to the web spaces.

F. Patient consent

It is mandatory that the patient well understands the difficulty and risks of the procedure, the functional implications of the donor site and the cosmetic problems. That’s why a lot of surgeons do not recommend the procedure in emergency, considering that the patient is not able in that moment to take the correct decision.

TECHNICAL CONSIDERATIONS

Preparation of the hand (Fig. 7)

After the stump(s) which will receive a toe transfer is incised and the previous scar is excised, the bone stump is prepared, then, the extensor and flexor tendons and the nerves ends are identified and dissected.

If the vessels are in good conditions and of good caliber they are prepared, but it is better to revascularise the transfer by doing the anastomoses to the dorsal branch of the radial artery in the anatomical snuff-box and to a dorsal vein; if so, these vessels are to be identified and isolated by an incision at the snuff-box level.

Harvesting of the toe(s)

Great toe

For avoiding the use of a free skin graft for covering the pedicle and also any tension on it, it is better to include in the transfer a small skin portion from the dorsal aspect of the foot. Then, the incision follows the course of the dorsalis pedis artery. It is also better to include a shorter triangular flap on the plantar aspect, proximal to the flexion crease. (Fig.8)
Whenever there is not a great cosmetic discrepancy between the great toe and the thumb, the whole great toe can be used. (Fig. 8)

In case of a big great toe, in the attempt of obtaining more similarity with the original thumb, there are two particular techniques that can be used: the wrap-around procedure and the trimmed procedure.

The wrap-around procedure consists in harvesting a soft tissue flap and nail from the great toe including or not a small segment of the second phalanx and reconstructing the bone structure using an iliac crest bone graft. A proximally based flap is conserved on the medial aspect of the great toe. (Fig. 9) This method has some disadvantages: great potential of the bone graft resorption, no growth potential and no movements. For avoiding these disadvantages, this method is better to be used for distal amputations in both emergency cases with proximal deglovement and sequel cases with proximal poor skin. The procedure consists in harvesting a soft tissue flap and the nail of the great toe but including only the second phalanx, entirely or partly. (Fig. 9)

The trimmed procedure consists in harvesting all the great toe by conserving a pedicled skin flap on its medial aspect and by resecting some bone in the attempt of obtaining a transfer with the same dimensions with the thumb and, more important, which keeps its growth potential and it is capable of motion. (Fig. 2) Therefore, this procedure avoids the disadvantages of the wrap-around procedure. It is very important that the medial collateral ligament and the periosteum elevated before the great toe is trimmed to be replaced for covering the bones.

**Second toe**

The same steps as previously described are to be used, but the dissection must be performed closer to the great toe. For the same reasons, the flap can also include some foot dorsal skin. (Fig. 10)

**Digital block of second and third toes**

The harvesting is identical as for the second toe, but in this case, the inclusion of some dorsal skin is mandatory for protecting the vascular supply of the third toe. (Fig. 11)

**Donor site closure**

It is better to be performed by a second surgical team. For the great toe donor site, in the attempt of conserving the metatarsal head, if a whole toe is transferred, the use of some local flaps to cover the stump is mandatory. If a wrap-around or trimmed procedure is used, the covering of the stump is obtained by using the preserved medial pedicled flap.

For the second toe, the resection of the metatarsal bone excepting its base facilitates the direct suture. If a digital block is harvested, the closure of the donor site is possible by partial direct suture and free skin grafting.
The osteosynthesis is realized by using a centromedulary K-wire or two “X” K-wires. After extensor and flexor tendons and nerves suture, the toe is revascularized by anastomosing the vein first and then the artery. All the wounds are sutured by avoiding any tension on the vascular pedicle; some of the wounds can be free skin grafted, if needed. The hand will be bulky dressed and immobilized.

**Postoperative care**

The postoperative care and monitoring includes:

- The room should be warm.
- The patient should be well hydrated and should receive some vasodilatation and anticoagulation therapy (papaverine, low molecular weight dextran, aspirin); the use of heparin is mandatory only in cases of a higher risk of thrombosis.
- Both donor foot and the recipient hand should be well elevated.
- In the first 4 days the toe transplant should be monitored each hour (skin temperature and color, Doppler flowmetry, flourmetry).

- The dressing is better to be changed as rare as possible, depending on the surgeon’s expertise.

RESULTS

The survival rate is about 95 percent, but in approximately 10-15 percent of cases some vascular problems could appear; in 5-7 percent of these cases the appropriate monitoring and, therefore, the possibility to promptly return the patient to the operating room solve the problem.

The range of motion of the transplanted toe depends on the condition of osteosynthesis, the strength of the tendon repair, the time of immobilization, but generally is about 75-90 percent from the opposite site. In all young patients, growth of the transferred toes was comparable with growth of the remaining toes. Abnormal nail growth, without deformity, was also observed.

Concerning the sensibility, in the first 4-6 months the patient feel like a toe; after 8-9 months the sensibility was well restored and the transplant is assimilated as a thumb or finger.

Concerning the donor site, if the described tactical and technical aspects are respected, generally any functional implications will arise.

OUR ATTITUDE

We consider the free digital transfer as the best method in hand fingers reconstruction, especially for the thumb. There are only few cases in which, due to various local conditions or to the patient willingness, we use methods as digital transposition or digital reconstruction using abdominal tube flap or Chinese flap armed with bones. Confronting usually with severe trauma affecting more than one digital ray, we consider that digital transposition cannot be used or it will loosen the already affected function of the hand.

The multistage reconstruction implies numerous uncomfortable procedures and the final result is not at all functional and aesthetically acceptable and also, if a nonvascularised bone is used, the phenomenon of bone resorption cannot be avoided.

Our technique is usually one with the accent on the anatomical dissection in the foot. We do not consider as mandatory the preoperative Doppler or arteriographic investigation. Regarding to the anatomical variation encountered, they superposed to the international references with a small observation concerning the increased number of absence or insufficiency of first dorsal metatarsal artery. In these cases a rigorous dissection of the plantar pedicle of the toes and the identification of their connections with the dorsalis pedis artery always allowed us to obtain a long and comfortable pedicle.

The possibility to work in two teams also improved our technique and allowed us to gain important hours and to use more complicated procedures as double free transfers or others multiple microsurgical procedures in the same time, even in emergency.

The finger chosen for transfer represents another important problem. After a long experience our preference for reconstruction of the thumb goes today for the great toe, for the amputations distally to the first MC head and for the second toe proximally. Like others surgeons we consider that the great toe accomplish the best the conditions for a new thumb regarding the shape, strength, aspect and function. Because the better appearance and function we prefer, whenever a whole great toe it is not possible to be used, the trimmed method. Proximal to the MP joint there are problems in choosing the toe. Considering the length necessary the great toe cannot be used because the resection of the first metatarsal will create static and dynamic problems. For the amputations situated at the MP joint, we prefer the second toe transfer. The second toe can be harvested with a long segment of metatarsal bone but usually this will create problems of local soft tissue coverage that will deserve complex procedures as of local flaps or second free flaps. Concerning the reconstruction of long fingers, we consider that it is mandatory to be performed if more than three digits are absent, but in case of only one or two absent fingers, we perform it on a special patient demand. The use of digital block or multiples toes transfers is indicated in very mutilated hands, this way being the only way to obtain a functional hand.

When the general condition allows the digital transfer in emergency, this one will shorten the evolution and avoid the post-amputation psychical disturbances of the patient. Emergency reconstruction must be understood as part of an emergency all-in-one reconstruction, preferable to be performed whenever a very complex trauma is present. (Fig. 10)

The possibility to work in two teams also improved our technique and allowed us to gain important hours and to use more complicated procedures as double free transfers or others multiple microsurgical procedures in the same time, even in emergency.

In conclusion, because the final purpose in hand reconstruction is the obtaining of a nearly normal morphological and functional recovery, we consider the toe(s) transfer(s) to be the method of election, which allows the use of the most similar anatomical structures for reconstruction.
NOTE

Part of this material was presented in the 13th European Course in Plastic Surgery (Porto/Vila Nova de Gaia, Portugal, November 8th-11th, 2004) before the European Board Examination in Plastic Surgery (November 12th-13th, 2004), and published in the Proceedings of the Course.

REFERENCES