12.1 Definition

Vascularized joint transfer is defined as a partial or complete joint transplant with preserved (pedicled transposition) [1, 2] or immediately restored (free microvascular) [3] blood supply.

A further subclassification can be made, with the clinically most relevant categories being: source of transplant, type of transplant, and donor site of transplant (Table 12.1).

Depending on the source, autologous (from the same patient), allogenic (from another human) or heterogenic (from another species) transplants can be distinguished. Allogenic joint transfer offers the possibility of an unlimited amount of tissue and the absence of donor site defects. Experimental studies on vascularized allogenic joint transfer reveal that these transplants show identical functional results compared to autologous vascularized joint transplants, provided there is adequate systemic immunosuppressive treatment [4], without which these transplants undergo rapid cartilage destruction and lose their function 6–8 months after transplantation [5]. Their clinical use is limited because of possible patient impairment (infections, late malignancies, etc.) from the lifelong systemic immunosuppression in the scope of missing vital threat. Under these circumstances such allogenic joint transplantations are ethically not justified in our opinion [6].

With regard to the type of transplantation, partial [7] or complete transplants can be distinguished. In a complete joint transfer, the whole functional joint capsule/joint cartilage/bone unit is transferred completely.

Table 12.1. Clinically most relevant subclassifications of vascularized joint grafts

1. Source of transplant
   - Autologous vs. allogenic and heterogenic

2. Donor site of transplant
   - Hand
     - Homodigital joint transfer
       - DIP–PIP (PIP–MP)
     - Heterodigital joint transfer
       - DIP–PIP
       - PIP–PIP
       - PIP–MP
       - MP–MP
   - Foot (2nd and 3rd toe)
     - PIP (toe)–PIP (finger)
     - MTP (toe)–MCP (finger)
     - MTP/PIP (toe)–MCP/PIP (finger)
     - MTP/PIP (toe)–PIP/PIP (finger)
     - MTP/PIP (toe)–MP/MP (finger)
     - MTP (toe)–CMC I (thumb)

3. Type of transplant
   - Complete joint transplant
   - Partial joint transplant
     - Monoarticular replacement
     - Biarticual replacement

The joint capsule is not opened, and therefore the internal “milieu” is not altered. Joint surfaces stay congruent to each other. In a partial joint transfer, there is significant impairment of the functional joint capsule/joint cartilage/bone unit. As the joint capsule is opened, there are significant changes in the internal milieu, subsequent scarring of the synovia and incongruent joint surfaces will face each other after transfer. Because P1 (basic phalanx) and P2 (middle phalanx) have two joint surfaces, there is the possibility that one (monoarticular replacement) or two (biarticular replacement) joint surfaces will have to be reconstructed.

Depending on the donor site, vascularized joint grafts can be harvested from the hand or the foot. Vascularized joint grafts from the hand [1, 2, 8–10] can be further differentiated into homodigital (from the same finger) [5, 11–13] and heterodigital (from another finger) [2, 3, 5, 14] joint grafts. This donor site offers the best joint grafts available although with the highest donor site morbidity.
Because of the high donor site morbidity, joint grafts from the hand are only taken following the so-called “tissue bank principle” according to Chase, i.e., from a finger that cannot be reconstructed, but which can be used as a graft donor for different tissues [2, 8, 12–16]. Vascularized joint grafts from the foot show similar anatomical features to finger joints but much less donor site morbidity when harvested. Therefore the foot has become of interest as a donor site for reconstruction of finger joints [5, 12, 13, 17]. The following techniques have been described in the literature: (1) vascularized proximal interphalangeal (PIP) (toe) joint transplantation for replacement of finger-PIP joint [5, 7, 12, 18]; (2) vascularized metatarsophalangeal (MTP) joint transplantation for replacement of finger-metacarpophalangeal (MP) joint [5, 19]; (3) combined vascularized transplantation of the MTP and PIP joint of the 2nd toe for replacement of two adjacent MP joints of the hand [5]; (4) combined vascularized transplantation of two MTP joints for the replacement of two adjacent MP joints of the hand [20]; (5) combined vascularized transplantation of PIP joint of the 2nd and 3rd toes for replacement of two adjacent PIP joints [5]; and (6) vascularized MTP joint transplantation for replacement of the carpometacarpal (CMC) joint of the thumb (Table 12.1).

12.2 Patients and Methods

In a retrospective clinical study, 16 vascularized joint transfers to the hand with an average follow-up of 8.2 (3–15) years were evaluated. The finger joint defect was caused by trauma in 12 patients, tumor in 2 patients and infection in 1 patient, as well as 1 patient presenting a congenital deformity. There were 14 men and 2 women. The mean age was 26 (2–42) years. In six cases a partial vascularized joint transfer was carried out, with the transplant being harvested in four cases from a non-replantable finger following the “tissue bank concept” according to Chase and in the other two cases from the PIP joint of the second toe. In ten patients a complete vascularized joint transfer was carried out, the joint being harvested from the hand in six cases and from the second toe in four cases (Table 12.2). The following criteria were evaluated: (1) active range of motion (Neutral-0 method), (2) postoperative arthritis, (3) growth, and (4) complications.

12.3 Results

The active range of motion of the transplanted joint for partial PIP joint transfer was Ex/Flex 0/20°/65° and for partial MP joint transfer it was 0/20°/30°. After distal interphalangeal (DIP)-to-PIP joint transposition, the active range of motion was measured to be Ex/Flex 0/20°/60°, after PIP-to-PIP transposition it was 0/30°/60° (Fig. 12.1a–f), after PIP-to-MP transposition it was 0/20°/80° and after MP-to-MP transposition 0/20°/57°. The results after microvascular PIP joint transfer from the second toe for PIP joint reconstruction were 0/25°/58° for PIP joint reconstruction and 0/15°/70° for MP joint reconstruction (Fig. 12.2a–k). Arthritic changes could be seen in three out of four patients with partial vascularized joint transfer. In all complete joint transfers there was no clinical and radiological evidence of arthrosis even after 15 years. In the two skeletal immature patients at the time of transfer, a normal growth compared to the contralateral donor site could be seen. Complications occurred in 8 out of 14 patients. In 4 cases tendolysis of the extensor tendon was necessary. In four patients skeletal malalignment (×3 sagittal plane, ×1 rotation) was diagnosed. In one patient flexor pulley reconstruction was necessary in order to correct a bowstring deformity.

12.4 Discussion

12.4.1 Partial Vascularized Joint Transfer

Transplantation of only one joint component is technically possible and is practised clinically [12, 21–26]. The main disadvantages of this technique are incongruent joint surfaces, lesions of the synovial sheath and postoperatively scarring with subsequent joint stiffness and joint malalignment. Because of the reduced mobility and the early onset of degenerative arthritis, partial vascularized joint grafts are a technically demanding operation with no significant advantage when compared to non-vascularized autologous partial joint grafts [12, 27, 28]. As only one joint component is denervated and postoperative degenerative changes occur, secondary pain at the reconstructed joint is possible. Nowadays indications for partial joint transplantation are exceptional; in an emergency situation after hand trauma one should always bear in mind the possibility of a vascularized partial joint graft from the hand in the context of “spare part surgery” or the “tissue bank concept”. If adequate joint material is available without creating a donor site defect, one should try to reconstruct even one-half of a joint if there is a good chance of functional improvement with additional joint movement and a low risk of impairment of global function. There are rare indications for partial vascularized joint transfer from the foot. Reconstruction of the thumb after transarticular amputation at the MP joint using a great toe transplant offers additional mobility at the thumb with acceptable onor site morbidity at the