PERSPECTIVE

The Colombo classification of free functional tissue transfer

G.N.S. Ekanayake[1], S. Manilgama[2]
[1]National Hospital of Sri Lanka.
[2]Colombo North Teaching Hospital, Sri Lanka.

Free flap surgery, an advanced microsurgical technique, entails the meticulous transfer of tissue from one area of the body to another. This innovative approach is commonly employed in reconstructive surgical interventions to restore both form and functionality following instances of trauma or cancer excision. Diverse classifications of flaps have been employed by different individuals over the years. The current classifications mainly focus on either anatomy or the composition of tissue types. The free tissue transfers describe only the structural reconstructive elements. The functional aspect of free tissue transfer is limited to muscle flaps. We believe that most of the emerging complex free tissue transfers now focus on functional recovery or functional reconstruction. The diversity of these free tissue transfers makes it difficult to formulate indications, principles of flap selection, goals of reconstruction, and anticipated outcomes and complications.

Free tissue transfers are mainly used in the reconstructive ladder as an advanced method to cover large defects or areas with no spare tissue for a local flap. These are classified into several types to identify and compare treatment options. They are primarily used for resurfacing or filling voids. However, some of these free tissue transfers have different goals in the reconstruction requirement. They could involve regaining or substituting a lost function or introducing a new function in the body. Free muscle transfers and free fibula for jaw reconstruction have been widely used for several decades (1,2,). With the expansion of knowledge and new types of flaps, these functional free tissue transfers have become popular. We have found that our reconstructions are now capable of providing more than just wound cover to patients. Currently, a classification for functional free tissue transfers is not available. Therefore, we are introducing a scientific classification for functional free tissue transfers (functional FTT). Concepts of classifying FFTT are an evolving science. These can be classified as

1. limb skeletal function (muscle, tendon, finger-toe) related

2. facial muscle, nose, and mandibular mobility (reanimation, nasal structure, mastication) related

3. functional conduit (bowel, vessels, lymphatic, nerve) related

Our classification, termed the "Colombo Classification of Functional Free Tissue Transfers," differentiates between conventional resurfacing type Free Tissue Transfers (FTT) and Functional FTT. This system aids in categorizing and outlining various enhancements to achieve optimal outcomes for different subtypes of reconstructions. Each functional FTT subtype has its unique standard and customized type, facilitating detailed comparisons.

The Colombo Classification of Functional Free Tissue Transfer

I. Limb skeletal function

A. Innervated muscle/ tendon

B. Innervated skin

C. Composite tissue (toe to hand transfers, vascularized joint transfer)

II. Facial skeletal function

A. Reanimation/muscle transfer (in facial nerve palsy)

B. Mastication (mandible, maxilla)

C. Recreating orifices (nose)

III. Functional conduits

A. Bowel (free jejunal, Ileal, colonic)

B. Lymphatic (lymph node transfer)

C.Uro-Genital tracts (penile urethra)

D. Nerve flaps

Correspondence: G.N.S. Ekanayake
E-mail: Plastichandpics@gmail.com
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Few examples of the proposed classification are given below.

I.A. Free functional muscle transfer (1).

There has been an exponential rise in the use of muscles for regaining lost function. The initial use of the gracillis as a functional transfer has been primarily for elbow or facial reanimation. Additionally, the gracillis has been utilized in shoulder and elbow extension. The adductor longus, a muscle that can be raised in a single pedicle, has opened the possibility of transferring two muscles with only a single pedicle. This double muscle transfer has allowed more muscles to be used in a paralyzed upper limb, enabling more joints to be motorized. Similar functions have been observed using the latissimus dorsi, medial gastrocnemius, and tensor fasciae latae.

I.B Free sensate flaps (3,4,5)

Fasciocutaneous flaps are generally not expected to regain sensory innervation as a primary goal. An increasing number of procedures are now combining sensory nerve coaptation during the anastomosis. This has been shown to improve sensory reinnervation of flaps in nearly three-quarters of flaps for lower limbs. Breast reconstruction with free tissue transfers is also considering reinnervation using the third intercostal nerve.

I.C. Free toe transfers (6):

The loss of fingers and thumbs presents a challenging scenario for reconstruction. Toe transfers offer a cosmetically acceptable and functional transfer option. Meta-analysis results of these transfers clearly demonstrate their superiority over prosthetic and insensate reconstructive options.

II. A. Free functional muscle transfer for facial reanimation (7,8,9):

Congenital and late presentations of facial nerve palsy are best managed with a new muscle used to mimic the essential movements of the face. The choice of muscles ranges from the gracilis to the extensor hallucis brevis and from the serratus to the pectoralis minor. The refinements of this time-tested free functional transfer can easily be placed under this arm of the classification. Every new innovative type of transfer can be easily categorized and referenced with comparative data from various centers.

II. B. Free tissue transfers for aesthetic and functional orifices of the face (10):

A relatively new type of free tissue transfer has provided hope by utilizing the nearly identical nature of the helical component of the ear for nasal defects. This approach has introduced another method of matching the caliber of the blood vessels by utilizing retrograde blood flow, resulting in both structural and optimal aesthetic outcomes.

II. C. Free fibula reconstruction of the lower jaw (2):

The human masticatory mechanism can be summarized as a complex grinding movement of the maxilla and the mandible. A stable maxilla and a mobile mandible provide the attachments to the dentition and the alveolar processes. Reconstruction of the main structure and refined dental implants on the construct has brought about different modifications to this osseous flap. Sometimes, the requirement of a skin cover is mandatory to resurface the defect. These flaps could be sourced from the fibula, iliac bone, scapula, or radius. Therefore, most of the reconstructions involve functional tissue transfers.

III. A. Free jejunal flap for esophageal reconstruction (11,12,13):

Esophageal and pharyngeal defects are managed according to an algorithm based on the extent of circumferential loss. Full circumferential loss and a significant gap would necessitate tube replacements as the optimal form of reconstruction. In this subcategory, there have been significant improvements and comparative data to ensure a successful therapeutic option for the patient.

III. B. Free Lymph Node Transfer (14)

Lymphedema (primary) or post-surgery lymphedema treatment is now increasingly reliant on lymphatic restoration using bypass techniques and free vascularized lymph node flaps. The main areas are lower limb lymphedema bypass and post-mastectomy lymph node transfer using groin nodes as a composite free tissue transfer. The flaps are raised similarly to fascio-cutaneous flaps, containing up to three nodes with their own vascular pedicle. The afferent/efferent lymph channels may be connected to the proximal ends of functioning lymphatics.

III.C. Free sensate radial forearm flap reconstruction of the penis (15,16):

Traumatic losses, therapeutic amputations, and gender affirmation surgeries have made this surgery popular. Refinements in this procedure are not frequently documented in literature. Urethral reconstruction is another neo-conduit within this category. Successful restoration of sensation in this type of free tissue transfer is seen as a mandatory component, while the erogenous aspect awaits more refined techniques.

III.D. Free Nerve flaps (17,18):

This entity is slow to gain popularity. However, the sural nerve or the peroneal communicating branch of the sural nerve has been utilized with a vascular pedicle to achieve better clinical results in cross facial nerve transfers. Studies have demonstrated faster recovery rates. As a recent development, our unit has utilized these in brachial plexus reconstruction.

Looking at this wide array of free tissue transfers, a classification is now in order. We believe this will open more doors to explore methodically. The following cases demonstrate some of these functional free tissue transfers.

Figure 1.a,b - Free functional gracillis transfer to restore elbow function. Nerve to gracillis was co-apted to a fascicle from ulna nerve.

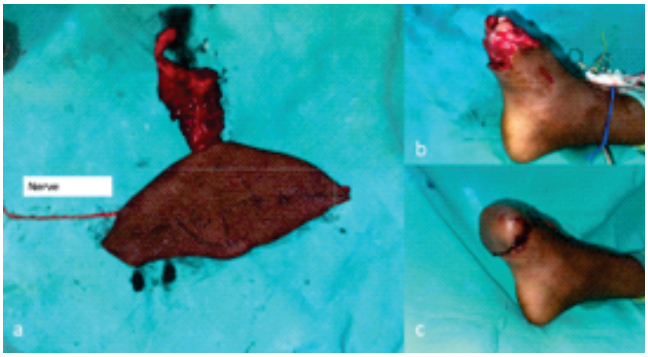

Figure 2 a,b,c - Free sensate antero lateral thigh flap to provide sensory reinnervation from deep peroneal nerve. The flap contains the lateral cutaneous nerve of the thigh**.**

Figure 3 a,b - Free great toe wrap to thumb transfer. the bony distal phalanx was reconstructed with an iliac bone graft. digital nerves and vessels reconnected.

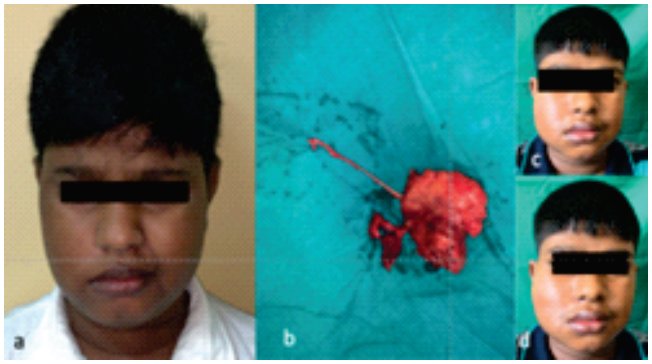

Figure 4 a,b - Free functional gracillis muscle has been used to elevate the angle of the mouth(4c,4d). For early re innervation part of the nerve to gracillis was coapted to nerve to masseter of the same side and other segment was coapted to one of the buccal branches of the normal side. Second transfer is expected to produce a spontaneous smile.

Figure 5 a,b,c - Left hemi nares total occlusion in an acid burn victim. No local flaps available. Ear helix used as a free tissue transfer to achieve best functional and aesthetic outcome.

Figure 6 a,b,c – Left hemi mandibular defect was reconstructed using free fibula osteo-fascio-cutaneous flap.

Figure 7 - Free radial forearm flap to reconstruct penis and the neo urethra. This male patient lost his penis due toa train accident..

Figure 8 - Sural nerve has been elevated with the vascular pedicle travelling together. The main connected vascular pedicle connected to the nerve was identified at the popliteal fossa.

Reference

1. Stevanovic M, Sharpe F. Functional free muscle transfer for upper extremity reconstruction. Plast Reconstr Surg. 2014 Aug;134(2):257e-274e. doi: 10.1097/PRS.0000000000000405. PMID: 24732655.

2. Sinno S, Rodriguez ED. Nuances and Pearls of the Free Fibula Osteoseptocutaneous Flap for Reconstruction of a High-Energy Ballistic Injury Mandible Defect. Plast Reconstr Surg. 2016 Jan;137(1):280-284. doi: 10.1097/PRS.0000000000001899. PMID: 26710032.

3. Chang EI. Latest Advancements in Autologous Breast Reconstruction. Plast Reconstr Surg. 2021 Jan 1;147(1):111e-122e. doi: 10.1097/PRS.0000000000007480. PMID: 33370068.

4. Ma S, Cheng K, Liu Y. Sensibility following innervated free radial forearm flap for penile reconstruction. Plast Reconstr Surg. 2011 Jan;127(1):235-241. doi: 10.1097/PRS.0b013e3181fad371. PMID: 21200218.

5.Hong JP, Kim EK. Sole reconstruction using anterolateral thigh perforator free flaps. Plast Reconstr Surg. 2007 Jan;119(1):186-193. doi: 10.1097/01.prs.0000244856.98170.9c. PMID: 17255672.

6. Del Piñal F. Extreme Thumb Losses: Reconstructive Strategies. Plast Reconstr Surg. 2019 Sep;144(3):665-677. doi: 10.1097/PRS.0000000000005983. PMID: 31461023.

7. Lin JT, Lu JC, Chang TN, Chuang DC. Simultaneous Reconstruction of the Lower Lip with Gracilis Functioning Free Muscle Transplantation for Facial Reanimation: Comparison of Different Techniques. Plast Reconstr Surg. 2018 Nov;142(5):1307-1317. doi: 10.1097/PRS.0000000000004849. PMID: 30113447.

8. Terzis JK, Olivares FS. Long-term outcomes of free-muscle transfer for smile restoration in adults. Plast Reconstr Surg. 2009 Mar;123(3):877-888. doi: 10.1097/PRS.0b013e31819ba316. PMID: 19319051.

9. Rozen SM. Facial Reanimation: Basic Surgical Tools and Creation of an Effective Toolbox for Treating Patients with Facial Paralysis. Part A: Functional Muscle Transfers in the Long-Term Facial Palsy Patient. Plast Reconstr Surg. 2017 Feb;139(2):469-471. doi: 10.1097/PRS.0000000000003025. PMID: 28121890.

10. Wang D, Qian Y. Reply: extended applications of vascularized preauricular and helical rim flaps in reconstruction of nasal defects. Plast Reconstr Surg. 2013 May;131(5):848e. doi: 10.1097/PRS.0b013e318287a016. PMID: 23629126.

11. Moradi P, Glass GE, Atherton DD, Eccles S, Coffey M, Majithia A, Speirs AJD, Clarke PM, Wood SH. Reconstruction of pharyngolaryngectomy defects using the jejunal free flap: a 10-year experience from a single reconstructive center. Plast Reconstr Surg. 2010

Dec;126(6):1960-1966. doi: 10.1097/PRS.0b013e3181f446a6. PMID: 21124134.

12. Chen HC, Rampazzo A, Gharb BB, Wong MTC, Mardini S, Chen HY, Salgado CJ. Motility differences in free colon and free jejunum flaps for reconstruction of the cervical esophagus. Plast Reconstr Surg. 2008 Nov;122(5):1410-1416. doi: 10.1097/PRS.0b013e31818820f4. PMID: 18971724.

13. Disa JJ, Pusic AL, Hidalgo DA, Cordeiro PG. Microvascular reconstruction of the hypopharynx: defect classification, treatment algorithm, and functional outcome based on 165 consecutive cases. Plast Reconstr Surg. 2003 Feb;111(2):652-60; discussion 661-3. doi: 10.1097/01.PRS.0000041987.53831.23. PMID: 12560686.

14. Brouillard P, Witte MH, Erickson RP, Damstra RJ, Becker C, Quéré I, Vikkula M. Primary lymphoedema. Nat Rev Dis Primers. 2021 Oct 21;7(1):77. doi: 10.1038/s41572-021-00309-7. PMID: 34675250.

15. Monstrey S, Hoebeke P, Selvaggi G, Ceulemans P, Van Landuyt K, Blondeel P, Hamdi M, Roche N, Weyers S, De Cuypere G. Penile reconstruction: is the radial forearm flap really the standard technique? Plast Reconstr Surg. 2009 Aug;124(2):510-518. doi: 10.1097/PRS.0b013e3181aeeb06. PMID: 19644267.

16. Al-Tamimi M, Pigot GL, Elfering L, Özer M, de Haseth K, van de Grift TC, Mullender MG, Bouman MB, Van der Sluis WB. Genital Gender-Affirming Surgery in Transgender Men in The Netherlands from 1989 to 2018: The Evolution of Surgical Care. Plast Reconstr Surg. 2020 Jan;145(1):153e-161e. doi: 10.1097/PRS.0000000000006385. PMID: 31881624.

17. Doi K, Kuwata N, Kawakami F, Tamaru K, Kawai S. The free vascularized sural nerve graft. Microsurgery. 1984;5(4):175-84. doi: 10.1002/micr.1920050403. PMID: 6513777.

18. Saffari TM, Bedar M, Hundepool CA, Bishop AT, Shin AY. The role of vascularization in nerve regeneration of nerve graft. Neural Regen Res. 2020 Sep;15(9):1573-1579. doi: 10.4103/1673-5374.276327. PMID: 32209756; PMCID: PMC7437604.