Nigerian Journal of Surgical Sciences 1997; 7:1-7

6th Eruchalu Memorial Lecture: Surgical Reconstruction: The Common Factor

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Ladies and gentlemen! Talking about Common Factors, my family holds a few things in common or, at least, nearly in common with the Eruchalus. While Raphael Chukwudile Eruchalu was born on 4th of March 1926, less than a year after my mother's birthday and less than a year before my father-in-law's, his son, Obinna Eruchalu, a practising surgeon in the US, was a contemporary, being one year my senior in the medical school. I knew him as a brilliant student in those days. He was also my wife's teacher as a lecturer in Anatomy.

I recount a brilliant performance by Eruchalu, junior, in the days of my surgical residency, though his training in surgery had not commenced by then. A young friend with whom he had been travelling had sustained a C5 or thereabout fracture and, while I wondered how he, the friend, managed to survive through the transportation to the hospital, I learnt of how the young 'surgeon to be' supported him while he was being transported to the hospital. In fact, if I may quote Professor Solanke in his comment on the Eruchalus' prowess, "Indeed surgery may be a hereditary disease".[1] Just before you start wondering whether it is the father or the son that is being honoured today, I wish to tell you of my overwhelming surprise on learning that I was to deliver this lecture.

I note that, since inception, this lecture series had always had the professorial touch. To follow the list of such previous lecturers is to me an honour and a special grace and favour of God. The first Eruchalu memorial lecture having been delivered in 1987 at Benin by Professor Festus Nwako, Professor of Paediatric Surgery, on `Medical Education - Time For A Major Change', the second in 1989 at Enugu by Professor Wilson Onuigbo, Surgical Pathologist, on Surgical Horizons', the third in 1991 at Lagos by Professor Toriola Solanke, Professor Emeritus of Surgery, on `Duodenal Ulcer in Nigeria; state of the art'; and the fourth in 1995 at Nnewi by Professor Emenike Anyiwo, Professor of Medical Microbiology and Immunology, on `Transplantation in Medicine: Matters Arising', I crave your indulgence, therefore, to bear with me for the next portion of an hour.

It had been noted that Eruchalu proved his mettle in gastro-intestinal surgery.[2] Therefore, he can be said to be a proponent of reconstructive surgery. I wish to note that, when the gastro-duodenal junction becomes scarred by disease, the commonest mode of management at the time of division of the vagus nerve is to reconstruct that area either by performing a pyloroplasty or fashioning a gastrojejunostomy. The pyloroplasty and gastrojejunostomy connection introduces a common link with reconstructive surgery which I have decided to speak about today, first by giving a definition, and, thereafter, by discussing it under four headings:

1. History of reconstructive surgery zeroing on reconstructive surgery as practised in Nigeria and particularly in Ibadan.
2. Scientific considerations in reconstructive surgery of the body surface.
3. State of the art of reconstructive surgery.
4. The future of reconstructive surgery with particular reference to Nigeria.

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6th Eruchalu Memorial Lecture given during the 32nd Conference of the International College of Surgeons (Nigerian National Section) on 26th April, 1997, at Ibadan, Nigeria.

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Definition: Reconstruction is the art of fitting tissues together (again) with the aim of achieving or simulating normalcy. Such tissues should have been previously deformed or defected. The definition thus excludes adjustment of body form covered under cosmetic surgery and also excludes transplantation which utilizes mostly allografts and immunological manipulation.

1. History of Reconstructive Surgery

The earliest reconstructive procedure under anaesthesia dates back to the beginning of the existence of man on earth when God caused a deep sleep to fall on Adam while He fashioned Eve out of a rib flap.[3] The Sushrata Sumhita, an Indian text written between 600 BC and 400 AD, contains record of nose reconstruction practised on those who had had their noses cut off as a punishment for their sins particularly adultery.[4]

During the later half of the last millennium and up to the earlier part of this millennium, surgery was shunned by physicians and relegated to charlatans and uneducated men. This hampered progress because a basic knowledge of anatomy was essential for reconstructive work. However, by the 16th century, things had started to change. A surgeon anatomist, Andreas Vesalius, in 1543, produced his beautifully illustrated book, `de Humani Corpori Fabrica', which was a detailed description of human anatomy.[5] This advance led to a significant progress in surgery.

Much later in the 18th century, John Hunter provided further advancement by discussing physiological and pathological bases of surgery, his works being based on myriads of experiments on animals. In 1878, the man, who introduced routine temperature monitoring to surgical care, performed intestinal resection and reconstruction. His name was Theodor Billroth. He revolutionized reconstructive surgery by performing the first successful gastrectomy (Billroth I operation).[6] One of the commonest reconstructive procedures, herniorrhaphy, was perfected to produce a very high cure rate by Bassini of Padua in Italy in 1887.[5]

Whereas Sir Astley Cooper grafted a full thickness skin in 1817 from an amputated thumb to the stump, it was Reverdin who stimulated skin grafting worldwide with his report in 1869 on pinch grafts.[7] The following year, Lawson, followed by Lefort in 1872 and Wolfe in 1876, used full thickness grafts; later, Thiersch and Ollier introduced the use of thin partial thickness skin for grafting.[8] Thus, while the art of reconstruction was being developed in abdominal surgery, the art was being perfected at the body surface simultaneously.

Ideas in reconstructive surgery described in 1892, e.g., island flap, transposition of the latissimus dorsi muscle in breast surgery, etc, were either short lived or not accepted.[9] On the other hand, surgeons became intent upon reconstructing defects by means of delayed tubed pedicle flaps that required many stages as described by Filatov and Gilles. Plastic and reconstructive surgery became established as a distinct specialty in consequence of the growth and interest in the field occasioned by the two world wars.[9]

At the beginning of this century, Alexis Carrel applied the technique of blood vessel anastomosis to transplant a loop of intestine for oesophageal replacement in dog.[10] In 1921, Nylen started to use the operating microscope for otorhinolaryngology in experimental animals.[11] Following Siedenberg's original report of free jejunal reconstruction of cervical oesophagus by revascularization in 1959,[12] clinical microvascular surgery came to being in 1964 when Malt and Mckhann successfully replanted an amputated arm.[13] Later on in 1972, McLean and Buncke[14] and, in the following year, Daniel and Taylor[15] reported the first microvascular tissue transfer. Since then, flap transfer in general has experienced rapid development and expansion. As opposed to the tubed pedicled flaps, mentioned earlier, these flaps are transferred in a single stage, therefore reducing morbidity.

Following the development in microvascular transfer, tissue replantation, i.e., reattachment of amputated parts, was first applied to the clinical situation in the 1960s as noted earlier. Concurrent with these, further improvements in the technique of skin grafting were introduced: first, in 1964, with Tanner, Vandeput and Olley's[16] method of skin graft expansion by meshing; secondly, in 1979, by Green et al[17] who cultured human keratinocytes, paving the way for the use of cultured skin in coverage of large body surfaces in the presence of small available donor skin.

Though Neumann[18] had reported the first clinical use of controlled skin expansion in 1957, it was not until 1976, when Radovan[19] reported his work, that the usefulness of this technique became obvious. Tissue expanders, using

silastic materials, have been used strikingly in breast surgery. Another use of silastic material in reconstruction is as a breast implant. This operation, at the wake of this decade, attracted protests from women particularly in America. Some of the catalogued disadvantages have, however, not been substantiated.

At Ibadan, reconstruction was carried out by surgeons like Ralph Eruchalu who were interested in repair in their areas of interest. Michael Tempest, who wrote up his management of cancrum oris in Ibadan in the *British Journal of Plastic Surgery,*[20] was one of the first in the practice of surgical reconstructions in Nigeria. Professor Anoma Ngu, former head of surgery, and Oritsejolomi Thomas, late Professor of Surgery and former vice-chancellor, as well as a host of other surgeons, who have passed through or are still working in Surgery Department, practised reconstructive surgery. However, Jeremiah Oluwasanmi, Professor of Plastic Surgery and former Head of Surgery, could be referred to as the first Nigerian Plastic Surgeon. In the 1980s, a Nigerian Association of Plastic and Reconstructive Surgeons was inaugurated; it was reinaugurated in 1995.

The following review of cases, which were performed by the Plastic Surgery Unit at the University College Hospital, Ibadan, in conjunction with various surgical specialties in the last 4 years, illustrate the common factor which reconstruction is. It will be noted that all the regions of the body and all surgical specialties are well represented:

- with head and neck: excision of nasal and lip tumours and forehead flap reconstruction.
- with otorhinolaryngology: orocutaneous fistula closure and pharyngeal repair with pectoralis major musculocutaneous flaps.
- with ophthalmology: release of ectropion and full thickness skin graft, as well as temporalis muscle flap transfer after orbital exenteration.
- with gynaecology: vaginal reconstruction using pudendal thigh flaps.
- with urology: release of penoscrotal contractures and local flap transfers.
- with neurosurgery: scalp rotation flaps to cover exposed skull and dura.
- with orthopaedics: repair of open fractures and chronic osteomyelitis by flap transfers.
- with cardiothoracic surgery: reconstruction of chest wall defects.
- with breast surgery: free transverse rectus abdominis muscle flap transfer for breast reconstruction after mastectomy.
- with abdominal surgery: excision of dermatofibrosarcoma protuberans and fascia lata closure.
- with paediatric surgery: reconstruction of a common anovaginal opening with fashioning of a perineal body.

2. Scientific Considerations in Reconstructive Surgery

A full thickness skin graft is that which includes both dermis and epidermis while a partial thickness skin graft contains both epidermis and part of dermis. A composite graft consists of more than one tissue element, for example, skin and cartilage. For a graft to survive, the bed on which it is laid must be able to supply nutrients adequately. This means that the bed must be satisfactorily vascularized. For any graft (whether skin, bone or otherwise) to survive adequately, nutrients must necessarily diffuse to the top layer of the graft. Thin grafts, therefore, tend to take under less favourable conditions. However, they shrink considerably and, when over flexor areas, cause flexion contracture.

The growth of any graft may be considered in phases:

(a) Graft adherence and plasmatic inhibition take place concurrently through fibrin bonding and diffusion of exudative nutrients from the bed. It is obvious, therefore, that, if the bed is unsatisfactory, graft take will diminish.

(b) Two days later, vessels start to grow from the bed to attach with those of the graft. At this stage, any undue shearing will produce vascular disconnection and haematoma. The graft is thus stable enough at day 5 to be viewed after dressings are taken down.

Successful reconstruction is synonymous with tissue viability. This, in turn, can only be ensured with a good knowledge of blood supply. The description of the vascularity of flaps provided the stimulus for anatomical correlation. As blood supply to the skin is now much better appreciated, the empiricism, tedious delay and poor results in reconstruction have been stripped aside.

Blood supply to the skin comes via 3 systems of arteries.[21] From these sources, blood is distributed to skin

at 3 levels, viz, subepidermal, intradermal and subdermal plexuses. It will be noted that the epidermis contains no vessels. However, the cells are nourished by diffusion of fluid from the subepidermal plexus. The 3 arterial systems that supply skin are direct cutaneous, fasciocutaneous, and musculocutaneous vessels.

The DIRECT CUTANEOUS system of vessels consists of certain arteries usually accompanied by veins which run in the subcutaneous fat parallel to the skin surface and confined to certain sites on the body. Examples of such vessels are superficial temporal, supraorbital, superficial circumflex iliac, and dorsalis pedis. They tend to run in a linear direction for some distance and, when incorporated in a skin flap, allow much greater length to breadth ratios to be achieved than would be possible in random pattern flaps. Such flaps are traditionally known as axial-pattern flaps.

Before discussing the next system of supply to the skin, a further clarification of axiality is pertinent. In as much as departure from the constraints of the traditionally taught length to breadth ratios may be achieved by axial pattern blood supply, some axial pattern flaps may be raised to extend beyond the vascular territory of the vessel concerned without showing necrosis. The resulting *dynamic territory* can therefore be seen to be larger than the *anatomical territory*.[21] Thus, there is a watershed between adjoining anatomical vascular territories which might undergo a shift if the intravascular pressure in one territory fell below that of the other. The distal end of an axial pattern flap is able to sustain a wider pancake of tissue on the end of the flap if a prior delay procedure had been carried out. This potential territory is the largest of all.

The FASCIOCUTANEOUS system consists of perforators which pass up to the surface along the fascial septa between adjacent muscle bellies and then fan out at the level of deep fascia, thereby forming a plexus which gives off branches that supply overlying skin. Examples include the regional suppliers of the limbs - radial and ulnar arteries, anterior and posterior tibial and peroneal systems. It is obvious that, when a flap is to be based on a fasciocutaneous system of vessels, such should be raised to comprise both skin and fascia[22] which in turn bears the main vascular supplies.

The MUSCULOCUTANEOUS source comes from the blood supply to muscle and reaches the skin by vessels which pierce the surface of the muscle, pass through deep fascia and then spread out mainly in the trunk. This is the basis for most of the versatile flaps like latissimus dorsi, and pectoralis major. In elevating such flaps it can be reasoned that the muscle or the part of it bearing the supply has to be lifted along with the overlying structures - all as a single unit.

Since the vascular supply of muscle is important in the elevation of flaps based on musclulocutaneous system, the classification of Mathes and Nahai[23] will now be considered: Type I muscles have only one vascular pedicle, e.g., gastrocnemius, and tensor fasciae latae. Type II muscles have one dominant pedicle usually entering close to the origin or insertion of the muscle with additional smaller vascular pedicles, e.g., gracilis, and soleus. Type III muscles have two vascular pedicles each arising from a separate regional artery (with the exception of orbicularis oris), e.g., rectus abdominis, and serratus anterior. Type IV muscles have multiple segmental pedicles of similar sizes, e.g., sartorius and tibialis anterior. Type V muscles have one dominant vascular pedicle and several smaller secondary segmental vascular pedicles, e.g., pectoralis major and latissimus dorsi.

It will be seen from the foregoing that the most useful muscles for reconstruction, i.e., those with the most abundant supply, fall within Type V. If a type I muscle is to be transferred, care must be taken not to divide it's only pedicle. Type IV muscles are not useful for reconstruction. In them, once more than 1 or 2 segmental pedicles are divided, cross supply from other segments cannot be ensured.

This brings us to the issue of nomenclature in flap surgery. A flap that consists of skin only is referred to as a cutaneous flap; one that consists of fascia and skin (thereby relying on fasciocutaneous system of vessels) is called fasciocutaneous flap; while the one that consists of muscle and skin (relying on musculocutaneous system) is called a musculocutaneous flap.

Within the first 3 days of reconstruction or flap transfer, anastomoses between the flap and recipient bed begin to develop. The newly formed vessels increase in size and they reorientate along the flap axis in the next one week.[24] Maximal flow is achieved on day 12 but, thereafter, flow begins to drop. Therefore, safe division of flap pedicles may be carried out at two weeks.

Systemic factors that regulate blood flow to the skin of a flap may be neural (sympathetic vasoconstrictor) or

humoral (cathecholamines, 5HT, prostaglandin F2X, histamine). Local factors include hypercapnia, hypoxia, acidosis, hyperkalaemia, and hypothermia. At surgery, therefore, adequate tissue oxygenation, hydration and warmth must be provided.

Of the factors that influence survival after vascular reconstruction, venous insufficiency appears to be top on the list. Attention in the last 10 years had been focused on ischaemia induced reperfusion injury (IIRI) which results from accumulation of oxygen derived free radicals elaborated during ischaemia and released at reperfusion.

Because reconstructed tissues are prone to vascular failure, it is important that they should be monitored through the operative and post-operative periods. The colour of the blood oozing from the edge of a flap is a good indicator of circulatory status. Flap colour as an indicator of flap survival is useful only in light complexioned individuals. The temperature of a failing flap drops lower than that of the surrounding. When a flap is pricked with a wide bore needle, the colour and briskness of blood flow may suggest which aspect of circulation has been compromised. Doppler ultrasound monitoring over vascular anastomoses has proved to be a most reliable method of detection of impaired circulation.

3. State of the Art

Armed with anatomical information, the surgeon can undertake reconstruction with an enhanced degree of safety. Patient morbidity and mortality have been reduced. Many lesions that would have been deemed unresectable or incurable and those avulsions, amputations and defects that had been previously passed over as unsalvageable or uncoverable are being dealt with with increasing reliability. For example, ultimate success of replantation is no longer judged in terms of survival of part but by functional as well as cosmetic parameters.[25]

For a thumb that could not be replanted at the time of injury, function can be partly restored by toe-to-finger or toe-to-thumb transfer. This method of `robbing Peter to pay Paul' is justifiable from the point of view of the importance of the part played by the thumb in hand function.

While still on the extremities, it is useful to note that the aim in surgery is to achieve primary wound closure. By this, I mean wound repair as soon as possible after presentation preferably within 24 hours. In developing economies, this ideal may be far fetched. However, at Ibadan, when the patient presents with a wound of some severity, while awaiting access theatre, we debride it, if necessary after regional block and apply honey soaks in casualty. Honey has a 3-way role of antisepsis:[26]

(1) through a low PH of about 3 which organisms cannot survive,

(2) through it's peroxidase enzymes that elaborate oxygen radicals which are toxic to organisms, and,

(3) through being hygroscopic, a property that renders the environment hostile to microbials. Open fractures with major soft tissue losses have in this manner (i.e., an initial debridement and dressing) been closed primarily to prevent the unfruitful complication of chronic osteomyelitis.

For a long time, Mclndoe's 2-stage vaginoplasty[27] had held sway in gynaecology. The undue morbidity of 2 stages, unwarranted complication of stenotic tightness from graft contracture and an unfancied lack of feeling at coitus (problem of sensitivity) have been conquered by several methods of local flap transfers. One of these flaps, the pudendal thigh flap,[28] has a triple role of being a single staged transfer, providing sensitivity from the posterior labial nerves that run along in the flap pedicle and, of course, obviating the problem of contracture.

In a similar fashion, lest you begin to think that reconstruction is sexist in nature, when there is absence or loss of penis from whatever cause, a free radial forearm flap may be utilized not only to rebuild penile tissue but also to construct a neourethra.[29]

Microvascular reconstruction has been utilized to augment blood supply in brain and cardiac ischaemia. In the case of brain ischaemia,[30] the ipsilateral superficial temporal artery is skeletonized and redirected, after distal division, through a craniotomy over the choice vessel. An end-to-side or end-to-end anastomosis is then performed to bypass the diseased vessel and deliver blood to distal structures. For cardiac bypass, a skeletonized mammary vessel is utilized in a similar fashion[31] to revascularize the portion of cardiac muscle involved.

A sub-specialty that demonstrates various facets of reconstruction is reconstructive breast surgery. When there is an available but hypoplastic breast tissue, a submammary breast implant may be inserted for augmentation. If, however, the breast has been removed, the choice depends

on adequacy of residual soft tissue. Where adequate, an implant may be placed under the pectoralis major. Where there is moderate inadequacy, the available tissue may be expanded and the expander subsequently replaced, after saline inflation, by a definitive implant.[32] When the inadequacy is severe as evidenced by tight scarring, presence of skin graft, etc, a latissimus dorsi pedicled flap may be transferred to the breast area[33] under which an implant may be inserted.

The beauty of reconstructive surgical armamentarium is aptly demonstrated in autologous breast reconstruction. The choice between a pedicled latissimus dorsi,[34] transverse rectus abdominis muscle[35] and gluteal[36] free flaps may be a difficult one. However, oftentimes, the reconstructive surgeon is spoilt for choice but he must be seen to be fair. Considerations like flap bulk, colour, hairiness, donor defect, flap reliability and dependency should be made. In planning musculocutaneous flaps, questions arise.[37] What is the vascular anatomy of the muscle? Is the muscle expendable? And what is the arc of rotation of the flap?

4. Future of Reconstructive Surgery

Human fetal surgery has been successfully performed for fetal urinary tract obstruction[38] and diaphragmatic hernias.[39] The scope is being extended. Of interest is the experimental finding that surgical repair in fetal animals does not result in scarring.[40] Thus, this phenomenon, apart from being applicable to yield good results in in utero repair, may be useful when its components are exploited for treatment of pathological processes. The possibility of manipulating adult wounds in order to produce (fetal like) scarless wound healing has been the basis of current research.[40]

Enhancement of in utero surgery has been produced with the advent of endoscopes. Intrauterine repair of cleft lip and meningomyeloceles has been made possible and it is expected that, barring other ethical considerations, more reports will appear in the literature. It is also now possible to harvest flaps with the endoscope. Indeed, new horizons continue to show up in reconstruction as advances are recorded in surgery.

Happily, the message of modern reconstruction is being spread yearly through the flap and microsurgery course of the University of Ibadan. With an average participation of 17 specialists per year, it is hoped that, by the year 2010, most surgeons will be practising the full range of reconstructive possibilities in their field.

Finally, towards the ultimate perfection of surgical reconstruction, we have to continue to draw from the wisdom of God who is the source of all knowledge.[3] Just as the Bible demonstrated the first surgical reconstruction and the necessary anaesthesia which accompanied it, and which came of age 6000 years later; and just as that same book predicted the establishment of the *common link* of all nations, the United Nations Organization, as well as formation of the nation of Israel, and the wonderful feat of humans flying in an aeroplane, all these in the same 11th chapter of Isaiah, I recommend, as the book does, that all specialists should take advantage of that *possible link* with the Master Specialist, the Almighty God, through the Saviour, Jesus Christ.

Ladies and gentlemen, thank you very much for bearing with me.

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