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LITERATURE REVIEW

# Microsurgical reconstruction of head and neck: a historical review

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## ABSTRACT

**Introduction**: The advent of microsurgery has become a critical development in the reconstruction of structures in the head and neck (H&N) region, which may be damaged for various reasons. With the practice of anastomoses integrated into microsurgery, new perspectives in reconstructing a wide range of lesions have emerged, greatly enhancing patient functionality and well-being through its high efficiency and excellent applicability. **Objective**: To review and chronologically organize historical data on the evolution of microsurgical reconstruction of the head and neck. **Methods:** Between January and April 2023, information was extracted from the PubMed/MEDLINE database by two independent researchers, adhering to the study's inclusion and exclusion criteria. Inclusion criteria encompassed peer-reviewed articles and relevant books published up to 2022 in Portuguese or English, primarily focused on the theme. Exclusion criteria included expert opinions, letters to the editor, and comments. **Results:** Significant innovations in microsurgery were observed predominantly during the 1970s and 1980s and this period marked the introduction of various new techniques and flaps, enhancing the effectiveness and appropriateness of reconstruction methods. **Conclusion:** Emerging in the 20th century, reconstructive microsurgery has since undergone significant advancements, particularly during the 1980s, with the development of various methods, technologies, and enhanced techniques. These advancements have led to numerous new techniques and improvements in older procedures.

**Keywords:** microsurgery; reconstruction; head and neck; flaps.

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## Introduction

In their nature, free microsurgical flaps are tissues whose blood supply has been interrupted and subsequently restored at another site[1]. These flaps were originally used for repairing and managing only body extremities[2]. Nowadays, they are utilized for large lesions and reconstructing many of the most challenging surgical cases, such as obliteration of cavities, transfer of muscles and nerves, protection of vital structures, and restoration of form and function. Although these are complex cases requiring expertise in the field, many of the procedures present a high success rate[1-3].

Microsurgical reconstruction in the head and neck (H&N) region began in a period of doubt and uncertainty because of concerns about the safety and reproducibility of the procedure[4]. Techniques involving the removal of free flaps from other parts of the body to the H&N region were ahead of their time, and have undergone many changes and improvements to reach the current state of the procedure[4].

The first record of microsurgical tissue transfer was by Seidenberg et al.[5] in 1959, where a jejunal flap was transferred to repair an esophageal defect. Subsequently, in 1975, Taylor and colleagues developed another method of transferring a fibula flap for mandibular reconstruction[6]. After these events, reconstructive microsurgery became renowned, and in the following years, it received the necessary investment for its progress[2,6,7]. In addition to these techniques, in 1978, Yang et al. described the free radial forearm flap, which proved ideal for reconstructing smaller defects of most soft tissues in the H&N region[2,6].

In the mid-1970s and 1980s, there were significant advances in the enhancement of microsurgical techniques used in H&N reconstruction[4]. For this, specific instruments, compatible donor flaps, and specialized training were important factors for the improvement and increased success rates of surgeries[4]. Consequently, the prevalence of complications like necrosis, infection, and blood loss was minimized[4,8].

Since then, free flaps have been widely used as a good option for microsurgical reconstruction in the H&N region, being useful for the transfer of bone and soft tissue, aiming for good esthetics and functionality for the patient[9]. Thus, any defect can be reconstructed according to criteria such as the number of flaps, structure, and appropriate resection[1]. However, this selection should be individualized and multidisciplinary, making the technique more complex for the novice surgeon[1].

This study focuses on reorganizing the innovations of microsurgery in the H&N region chronologically, by each decade, that have made this field what it is today.

## Objective

This study aims to review and analyze the historical evolution of microsurgical reconstruction in the H&N region from its inception to the present day.

## Methods

This article is a literature review, with information extracted from the PubMed/MEDLINE, Google Scholar, and SciELO databases. It aims to review and compare studies published and related to the topic of microsurgical reconstruction in the H&N region.

The search was conducted in January, February, March and April 2023, by two independent researchers, adhering to the study's inclusion and exclusion criteria.

The inclusion criteria are peer-reviewed articles and relevant books published up to 2022, in Portuguese or English, whose main subject was compatible with the theme in a non-specific manner.

Expert opinions, letters to the editor, and comments were excluded, as were articles published in languages other than Portuguese and English.

## Development

- Definition, Concept, and Importance

Microsurgery describes a set of techniques that require specialized instruments. These instruments are characterized by the three "Ms": microscope, micro-instruments, and micro-sutures[10]. By definition, the use of a flap in this surgery involves tissues whose blood supply has been interrupted and then restored at another site[1]. Thus, flaps in reconstructive microsurgery have become vital for managing defects in H&N surgery, particularly in oncological and traumatic cases[11]. Their use has become popular because of the ability to transfer both bone and soft tissue simultaneously, offering a wide range of reconstruction options in the H&N region[1]. The method is highly complex, involving surgeries performed over extended periods and requiring considerable experience and training by the surgeon and their team[3]. The ability to perform increasingly smaller anastomoses on vessels and nerves has been gaining strength, transforming the perception and scope of reconstructive microsurgery[10,11]. Consequently, various specialties such as ophthalmology, neurosurgery, and gynecology also employ this technique[10].

- How it all began ...

Microsurgery had its roots in the early 20th century when Alexis Carrel, in 1902, performed the first anastomosis (Table 1) using the end-to-end triangulation technique, which is still widely used today[12]. Following this, in 1906, Goyanes performed the first vein graft[10]. A few years later, Carrel and Guthrie completed the first organ transplant in a laboratory, for which Carrel was awarded the Nobel Prize in Medicine and Physiology[10]. Additionally, in 1916, Jay McLean, a student at Johns Hopkins University, discovered heparin, an anticoagulant that served as one of the pillars for enabling microsurgery, and is still currently widely used[10,12,13]. Consequently, in 1921, Carl-Olof Siggesson Nylén, also known as the father of microsurgery, constructed the first binocular surgical microscope, initially used for animal surgery and later for correcting deafness[10]. The idea of immediately reconstructing defects in the H&N region was first advocated by Edgerton in 1951[13]. For this reason, flaps from different parts of the body began to be created[13]. The aforementioned microscope underwent various modifications and purposes over the years and, in 1952, Littmann built his microscope equipped with lights, intended for use in colposcopy and otoscopy exams[10]. Following these developments, many surgical areas like ophthalmology and neurosurgery began to adopt the microscope, and numerous procedures, previously considered improbable, were achieved[10,12]. However, the first microsurgical reimplantation was performed in Japan in 1958 by Onji and Tamai[10,12], which involved the reconstruction of an injured

**Table 1.** History of events and achievements in microsurgery.

| Year | Physician | Event |
|---|---|---|
| 1902 | Alexis Carrel | 1st anastomosis[12] |
| 1906 | Goyanes | 1st vein graft[10] |
| 1916 | Jay McLean | Discovery of heparin[10] |
| 1921 | Carl-Olof Siggesson Nylén | 1st surgical microscope[13] |
| 1951 | Edgerton | Creation of flaps[13] |
| 1952 | Littmann | Creation of microscope with lights[10] |
| 1958 | Onji and Tamai | 1st microsurgical reimplantation[10] |
| 1959 | Seidenberg et al.[5] | 1st microsurgical reconstruction of head and neck in a dog |
| 1960 | Jules Jacobson | Emergence of the term "microsurgery"[12] |
| 1963 | Jules Jacobson | Creation of microsurgical instruments[12] |
| 1968 | Cobbett | 1st microsurgical application of hand reimplantation[14] |
| 1971 | Strauch et al.[15] | 1st use of anastomosis in microsurgery |
| 1972 | Harii | 1st hair transplant[13] |
| 1972 | O'Brien | Creation of microsurgery laboratory[13] |
| 1973 | Daniel and Taylor | 1st free cutaneous flap[12] |
| 1975 | Taylor | 1st procedure involving fibula bone tissue[13] |
| 1976 | Harii | Use of musculocutaneous flap in Bell's palsy patients[12] |
| 1976 | Baker and Panje | 1st free cutaneous flap for head and neck reconstruction[12] |
| 1979 | dos Santos | 1st clinical application of scapular flap[16] |
| 1979 | Taylor | Usefulness of the deep circumflex iliac artery (DCIA)[16] |
| 1979 | Watson | 1st application of the latissimus dorsi flap in head and neck[17] |
| 1980 | Franklin | Use of DCIA for mandibular reconstruction[18] |
| 1981 | Yang | Development of the radial forearm flap[19] |
| 1982 | Song | Development of the lateral arm flap[12] |
| 1982 | Gilbert and Teot | 1st transfer of the free scapular flap[12] |
| 1983 | Chen and Yang | Development of the osteocutaneous fibular flap[12] |
| 1984 | Song | Identification of three types of flaps: anterolateral, anteromedial, and posterior forearm[16] |
| 1984 | Song | 1st description of the anterolateral thigh flap[16] |
| 1985 | Maruyama | Use of the osteomyocutaneous latissimus dorsi flap for perforating mandibular injuries[18] |
| 1986 | Soutar and Widdowson[18] | Radial soft tissue and radial bone for facial reconstruction |
| 1988 | David et al.[19] | New technique of DCIA flap |
| 1989 | Soeda | Perforator flap[12] |
| 1989 | Chantrain | 1st use of the forearm flap for laryngopharyngeal reconstruction[12] |
| 1989 | Hidalgo | 1st use of the fibula flap[17] |
| 1993 | Koshima | Popularization of the anterolateral thigh flap[12] |
| 1997 | Koshima | Introduction of the term "supramicrosurgery"[20] |
| 1997 | Urken | 1st description of the use of the forearm flap for cricoid cartilage reconstruction[21] |
| 1999 | Wei et al.[22] | 1st use of 2 flaps simultaneously in head and neck |
| 2004 | Wei and Mardini[23] | Creation of the term "free-style flaps" |
| 2005 | Wei et al.[24] | New concept of perforator flap |
| 2005 | Devauchelle | 1st allogenic microsurgical face transplant[13] |

limb. The first record of microsurgical reconstruction in the H&N region was in 1959 by Seidenberg et al.[5], involving the transfer of jejunal intestinal segment tissues from a dog for the reconstruction of an esophagus affected by cancer.

In 1960, Jules Jacobson performed the first anastomosis of a vein smaller than 1.4 mm, thus coining the term "microsurgery"[12]. Three years later, in 1963, Jacobson developed microsurgical instruments that are still widely

used today[12]. Also in 1963, Buncke and Schulz[14] reported an amputation and subsequent microsurgical reimplantation of an ear in a rabbit using vein anastomosis.

- Application of microsurgery in the H&N region

### • The 1970s

During the 1970s and 1980s, there were various significant achievements in the evolution of H&N procedures worldwide[13]. For instance, in 1971, Strauch et al.[15] noted that the transfer of bone tissue for reconstruction was impeded by a lack of blood supply. Their study described the transfer of bone and soft tissue from a dog's rib for jaw reconstruction, which was only possible using the technique of microsurgical anastomosis[13,15]. Concurrently, Noel Thompson[25] conducted studies on reconstruction using muscle flaps in people with facial paralysis. However, the technique used was not satisfactory for large flaps, resulting in weak muscle contraction[13,25]. Additionally, in 1972, a significant event was the creation of the International Society of Reconstructive Microsurgery and its first symposium, held in Vienna, Austria[13]. In the same year, Harii and colleagues performed the transfer of scalp tissue from the temporal area for hair transplantation[13]. Another noteworthy development contributing to the advancement of the procedure was the establishment of a microsurgery laboratory for teaching purposes in Melbourne, Australia, by O'Brien in 1972, contributing to clinical patient care and the basic physiology of the procedure[13]. In 1973, Daniel and Taylordescribed the first free cutaneous flap[12]. In 1975, Taylor et al.[13] also published the first study describing a procedure using bone tissue from the fibula, recognized as excellent for reconstructing large bone defects, including extremities, mandible, and maxilla in current practice.

With such knowledge disseminated around the world, various tissues began to be discovered and refined using the microvascular technique[13]. In 1976, Harii et al. used one of the first musculocutaneous flaps to completely remove the gracilis, thereby reconstructing the face and restoring expression in patients with Bell's palsy[12,13]. In 1976, James reported a case of a girl whose facial lips and part of her nose were amputated by a dog bite and were subsequently successfully reimplanted[13]. In the same year, Baker and Panje applied a free cutaneous flap for reconstruction in the H&N region[12].

By the end of the 1970s, many studies addressing tissue reimplantation were conducted, showing high success rates and highlighting the need for postoperative care[13]. Alongside this, many important studies were carried out in the area of peripheral nerve repair. In 1976, Millesi and colleagues[13] achieved good results in most of their experiments using nerve flaps. In 1978, Saijo was the first to propose, theoretically, the efficiency of the scapular flap with the circumflex scapular artery pedicle[16].

The myocutaneous flap was described for the first time in 1979[16]. Another important discovery in 1979 was Taylor et al.description of the relevance of the deep circumflex iliac artery in supplying the anterior ilium and skin[16].

Concurrently, Watson performed the application of the latissimus dorsi flap for reconstruction in the H&N region[17].

### • The 1980s

At the beginning of the 1980s, reconstructive microsurgery began to gain popularity[16,21]. Various studies and advancements contributed to its renown because of new techniques and higher success rates in functionality and esthetics[16,26]. For example, the first report of using the free temporoparietal flap was for reconstructing the back of the hand[21]. In 1982, Song et al. performed more than 50 successful forearm flap transfers, confirming their excellent applicability in H&N reconstruction[12,16].

Franklin and collaborators, in 1980, popularized the osteocutaneous groin flap for mandibular reconstruction[18]. A year later, Yang et al. developed the radial forearm flap, which has since been widely used for H&N reconstructions[19]. In subsequent years, the applicability of the forearm flap for intraoral reconstruction was demonstrated by various authors. Song and colleagues, in 1982, introduced the lateral arm flap, which is similar to the forearm flap but thinner and narrower[17]. Simultaneously, Gilbert and Teot reported the first transfer of the free scapular flap[12]. In 1983, Chen and Yang presented the novel osteocutaneous fibular flap[12].

Following these events, many surgeons began seeking new types of flaps to meet specific needs. In 1984, Song et al., while studying forearm circulation, discovered that veins in the intermuscular septum could be used as a pedicle[16]. From this study, three types of flaps were developed: anterolateral, anteromedial, and posterior forearm[16]. The first description of the anterolateral thigh flap (Figure 1) was reported by Song et al. in 1984[16]. Despite its potential, it did not gain popularity at the time. In 1985, Maruyama and collaborators proposed the osteomyocutaneous latissimus dorsi flap for the reconstruction of perforating injuries in the mandible[18].

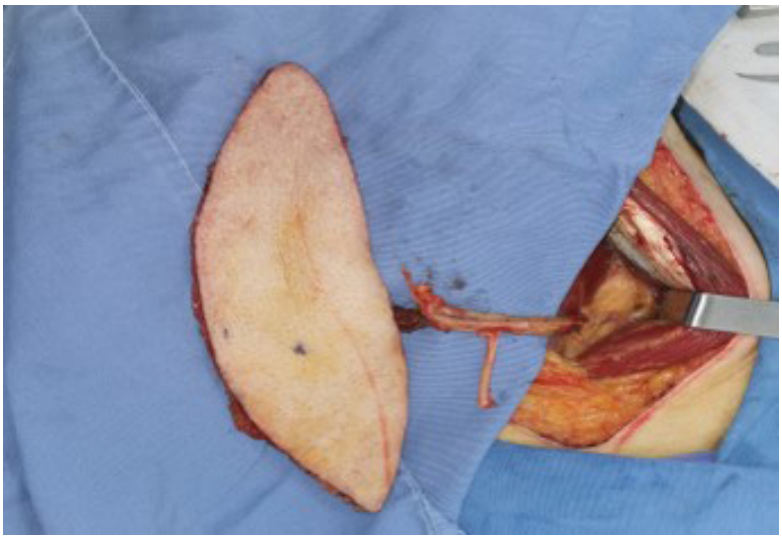

**Figure 1.** Anterolateral thigh microvascular flap.

**Credit:** Dr. Gabriel Manfro.

In 1986, Soutar and Widdowson[18] realized that the combination of radial soft tissue and radial bone would be the best option for facial reconstruction, thus making this technique very common in various procedures. In 1988, David et al.[19] established a new concept by resecting part of the iliac crest and using the deep circumflex iliac artery for mandibular reconstruction, confirming a significant reduction in morbidity in the procedure. The term "perforator flap" was introduced in the study of Koshima and Soeda[27] in 1989, where the used flap differs from the musculocutaneous abdominal flap by not containing muscle tissue, solving problems like herniation of the donor site. Furthermore, this technique is based on the fact that the use of adjacent tissues is not always necessary, thus avoiding unintended tissues by isolating the perforating veins. In the same year, Chantrain was the first to use the forearm flap to reconstruct the laryngopharynx[21].

Still in 1989, Hidalgo employed for the first time the fibula flap with osteotomies to approximate the natural anatomy of the mandible to be reconstructed[17]. Since then, the fibula flap (Figure 2) has proven advantageous for reconstructing extensive defects[17]. Concurrently, Koshima and Soeda[27] introduced the perforator flap from the deep inferior epigastric artery.

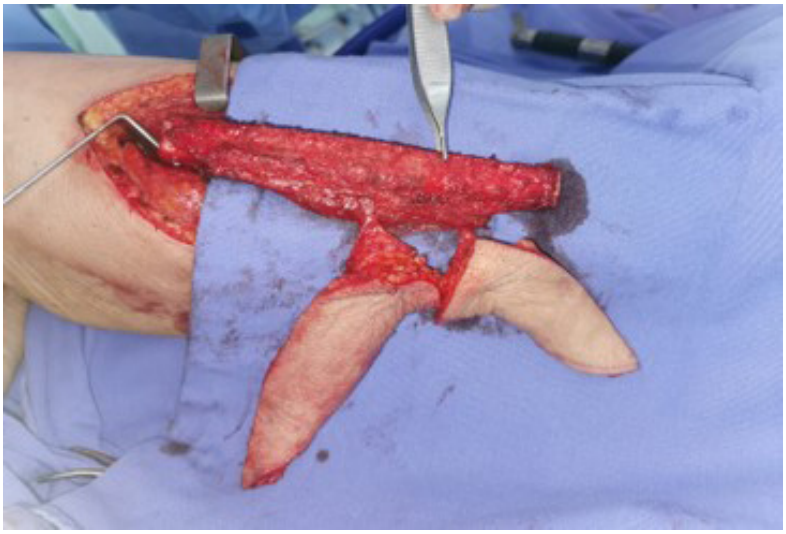

**Figure 2.** Fibula microvascular flap.

**Credit:** Dr. Gabriel Manfro.

### • The 1990s

Koshima et al. and Kimata et al., in 1990, studied the anterolateral thigh flap and began to gain prominence in H&N surgery[12]. However, it was only a few years later that the use of this flap was consolidated by surgeons. In 1996, Brown[28] first described the flap from the deep circumflex iliac artery along with the internal oblique muscle for mandibular reconstruction.

In 1997, Koshima introduced a new term: "supramicrosurgery"[20]. This term refers to surgery capable of performing anastomoses of nerves and veins with

a caliber <0.8 to 0.5 mm in diameter, which led to the development of new reconstruction techniques[20]. Also in 1997, Urken and colleagues described the use of the forearm flap (Figure 3) for reconstruction of the cricoid cartilage for the first time[21]. In 1999, Wei et al.[22] demonstrated the efficiency of using two flaps simultaneously for H&N reconstruction.

**Figure 3.** Forearm microvascular flap.

**Credit:** Dr. Gabriel Manfro.

### • From the 2000s to the present day

In the 2000s, the technique developed by Koshima, known as the perforator flap, became popular[29]. This technique involves removing the desired flap without interfering with the local muscle functionality[29]. The consolidation of success and dissemination of the anterolateral thigh flap was achieved by Wei et al.[21] and Celik et al. in 2002, leading to its widespread use in H&N reconstruction around the world, solidifying its popularity as the first choice for soft tissue reconstruction[20]. Two years later, in 2004, Wei and Mardini[23] developed a new concept from the 1997 conception of supramicrosurgery. Wei realized that, with the advent of perforator flaps, any cutaneous surface of the body could be used to harvest flaps without damaging the local muscle[23]. Furthermore, Doppler ultrasonography is capable of mapping veins in any region of the thigh that shows a positive signal for the examination. Thus, the concept of "free-style flaps" was created[23]. With the aid of Doppler ultrasonography, any flap can be harvested without complications regarding the size and anatomy of the veins. Wei was also the first to have a retrograde approach to the vascular pedicle, tracing from the perforating vein back to the main branch[23].

In 2005, Wei and collaborators[24] realized that the anterolateral thigh flap, which had been widely used for reconstruction, could be combined with various other tissues because of its versatility. However, there was no consensus on the ideal nomenclature. Therefore, any cutaneous flap requiring intramuscular dissection is then called a perforator flap[24]. In the same year, Devauchelle et al.

were able to perform the first allogenic microsurgical face transplant, including the nose, lips, and cheeks[13].

## Final remarks

The origins of reconstructive microsurgery date back to the early 20th century. Since then, various methods, technologies, and techniques have been developed for its enhancement. The 1980s, in particular, marked significant advances in the discovery of new flaps. Numerous benefits from a morphological, functional, and morbidity standpoint were achieved. However, this is a procedure of extreme complexity that requires well-trained surgeons and a multidisciplinary team. In conclusion, this evolution is laborious, demanding training and investment for the emergence of new ideas and, consequently, continual progress in microsurgical reconstruction in the H&N region.

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