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To the editor of Oral Oncology

Dear Editor,

Please find attached a review manuscript, entitled ‘***Head and Neck Reconstruction with Free Flaps Based on the Thoracodorsal System’*** that I would like you to consider for publication in your Journal.

Please note that there was no funding for this research, and that the authors do not have commercial associations, current and within the past five years, that might pose a potential, perceived or real conflict of interest.

Please let me know if you need any further information.

Yours sincerely,

John Edward O’Connell*

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Highlights

- The Thoracodorsal system (forms part of the sub-scapular system) provides a wide range of soft and hard tissue free flaps, as well as chimeric options, for head and neck reconstruction
- Latissimus Dorsi, Thoracodorsal Artery Perforator, and Tip of Scapula are main flaps available
- Particularly useful in vessel deplete necks, multi-surface defects, elderly patients
- Its use has been well described in mandibular, maxillary, mid-face, and scalp defects
- Technically challenging, but low morbidity relative to other free flap options

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Head and Neck Reconstruction with Free Flaps Based on the Thoracodorsal System

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Head and Neck Reconstruction with Free Flaps Based on the Thoracodorsal System

Abstract

The advent or micro-vascular free tissue transfer has facilitated the reconstruction of increasingly complex Head and Neck defects. There are multiple donor sites available, each with its' own advantages and disadvantages. However, the subscapular system, including the thoracodorsal system, provides the widest array of soft and hard tissue flaps, as well as chimeric options. Its advantages include a long pedicle, independently mobile tissue components, relative sparing from atherosclerosis, and minimal donor site morbidity. The soft tissue flaps available from the thoracodorsal system include the Latissimus Dorsi, and Thoracodorsal Artery perforator flaps, while the tip of scapula provides the hard tissue component. This review paper outlines the anatomical basis for these flaps, as well as describing their utility in head and neck reconstruction.

Introduction

Evolution in the range of free flaps available for head and neck cancer has facilitated successful reconstructive surgery in increasingly demanding defects. Patients presenting with extensive primary or recurrent tumours, as well as cases of osteoradionecrosis, form a significant part of the head and neck reconstructive surgeon's practice. These cases often incorporate complex three-dimensional defects that include both hard and soft tissue components as well as more than one epithelial surface (e.g. mucosa and skin). Microvascular free tissue transfer is considered the gold standard in these complex cases and the choice of flap is varied and dependent on factors including the site, size, complexity of the defect as well as patient co-morbidities and indeed surgeon training and preference. The Thoracodorsal system offers both soft and hard tissue flaps as well as chimeric options. The common soft tissue flaps are the Latissimus Dorsi (LD) and Thoracodorsal Artery Perforator (TDAP) flaps, whilst the Tip of Scapula (TSCAP) remains the predominant hard tissue component, with or without additional soft tissue elements. We, herein, provide a review of the anatomical basis of these flaps and their relevance to reconstruction within head and neck practice.

Overview of Thoracodorsal Vascular Anatomy

Figure 1 summarises critical aspects of thoracodorsal arterial anatomy relevant to the reconstructive surgeon. The subscapular artery is the largest branch of the axillary artery with a mean diameter of 6mm (range 4 – 8mm)[1]. Both it and the subscapular vein arise from the posterior surface of the third part of the axillary artery and vein, following the inferior margin of the subscapularis muscle for 2.2cm (range 2 – 3cm), before dividing into two terminal branches, the circumflex scapular and thoracodorsal arteries and veins respectively. The subscapular artery and vein arise in close proximity in the vast majority of cases. In those cases where the artery and vein originate separately, the subscapular artery lies proximally in the axilla by an average of 4.2cm[2, 3]. In addition, it should be noted that the thoracodorsal artery arises directly from the axillary artery in 0.8 – 3% of cases[1, 4, 5]. In some instances it may even arise from the lateral thoracic artery.

The thoracodorsal vessels travel cephalo-caudally along the lateral border of the scapula, through the fatty tissue of the axilla, before entering the hilum of the Latissimus Dorsi muscle. The mean length of the thoracodorsal pedicle between origin and muscular hilum is 9.3cm (range 6 – 16.5cm). At its origin, the mean diameter of the artery is 2.7mm (range 1.5 – 4mm) and the vein is 3.4mm (range 1.5 – 4.5mm)[2]. Along its course to the muscle the thoracodorsal artery supplies named branches to the tip of scapula (angular branch), and to a number of muscles including subscapularis, teres major, and serratus anterior. The angular branch is reported as being consistent and has a mean pedicle length of 6.83 cm (range 2.5 – 8cm).[6] Anecdotally however we have found it to be missing or diminutive in a small minority of cases (5%). It is of considerable relevance that the thoracodorsal system, relative to other vessels (particularly those in the lower limb and pelvis used to harvest vascularized bone[7]), is spared from atherosclerotic changes[1, 4].

Cadaveric dissections have demonstrated that in 92% of cases, the thoracodorsal artery and vein cross the axilla together. In the remaining cases, the artery and vein may not join until the takeoff of branches to the serratus anterior. The thoracodorsal artery sends just one branch to the serratus anterior in 54% of cases, with 2 or 3 branches less frequently[1]. In approximately 1% of cases, the thoracodorsal artery does not send a branch to the serratus anterior muscle[8].

Latissimus Dorsi (LD)

First described by Tansini in 1896[9] as a pedicled skin rotation flap and subsequently as a musculocutaneous flap, the LD has a long history in thoracic and limb reconstruction. Although described by Quillen[10] in 1978 as a pedicled flap in head and neck reconstruction, Maxwell[11] first reported its use in free tissue transfer, also in 1978. Ease of dissection, large surface area, and length of the vascular pedicle are some of reasons that account for the popularity of the free LD flap.

The LD is a fan-like muscle originating medially and extending from the dorsal iliac crest caudally and travelling cranially via the sacral, lumbar, and thoracic (lower 6) vertebrae. The fibres insert into the humerus via a space between teres major and pectoralis major. Along with the teres major, it forms the posterior axillary fold[12, 13].

Within the LD, the thoracodorsal artery divides into transverse and vertical branches in 94% of cases, thus forming the anatomical basis for splitting the muscle longitudinally in order to harvest two separately vascularised muscular or musculocutaneous units (the thoracodorsal nerve parallels the vessel). In the remaining 6%, the vessel divides into 3 or 4 parallel vessels, which traverse the muscle[14]. The transverse branch usually runs parallel to the free upper border of the LD muscle, 3.5cm from the edge. The vertical branch usually takes a cranio-caudal course towards the iliac crest, 2.1cm from the lateral edge of the muscle. These branches then become intra-muscular. These intra-muscular branches of the thoracodorsal artery supply the musculocutaneous perforators on which the TDAP flap is based. The anatomical basis for the TDAP flap will be outlined in more detail below.

Based on the work of Taylor and Palmer [15], the LD is divided into three angiosomes. The most proximal segment is supplied predominantly by the thoracodorsal artery, with the middle portion by the posterior intercostal arteries, and the distal segment is supplied by the lumbar arteries. Therefore, the skin paddles overlying the distal angiosome are less reliable when based on the thoracodorsal pedicle only.

Owing to the high success rate with microvascular free tissue transfer, and increased versatility in flap design, the LD is now more commonly used as a free rather than pedicled flap. A failure rate of 0-8% has been described for the free LD used in head and neck reconstruction[16, 17, 18]. The ability the utilise the vascular anatomy, and split the muscle longitudinally with 2 separate skin paddles based on the transverse and vertical branches of the thoracodorsal artery respectively, allows the reconstruction of multi-surface oral defects [19, 20]. In our practice the main indication for this broad flap is in the reconstruction of large scalp, mid-face and skull base defects either in isolation or as a chimeric flap including bone sourced from the scapula. This is in keeping with other units [21, 22, 23]. **Figure 2** demonstrates an example of LD-TSCAP chimeric flap from our own series.

In 2014, Lee and Mun[24] performed a systematic review of functional donor-site morbidity after LD muscle transfer and found that while functional impairment of the shoulder could occur, there was little evidence for interference with activities of daily living. As one would expect, the muscle-sparing LD and TDAP flaps showed lower functional morbidity.

While the focus of this review is primarily on free tissue transfer, the pedicled LD does have a potential role in salvage surgery and/or in patients with vessel depleted neck, and is included for completeness. Relative to other pedicled regional flaps, for example the pectoralis major, the pedicled LD has advantages including a broader surface area and a less obvious scar. The reported success rate is 80-90%[25, 26, 27, 28]. Like all flaps the pedicled LD is not without its disadvantages[29] including a requirement to turn the patient (precluding simultaneous tumour ablation and flap raising), prolonged wound drainage and seroma formation, and risk of injury to the brachial plexus[30]. In addition to these reported disadvantages, we have found that the pedicled LD has a propensity to pull away from defects in the head and neck, presumably due to the weight of the flap, and also carries a significant risk of vascular compromise as a result of venous occlusion at the apex of pedicle rotation.

Thoracodorsal Artery Perforator (TDAP) Flap

Angrigiana et al[31] and Spinelli et al[32], in 1995 and 1996 respectively, described the TDAP flap, which is based on perforators arising from the thoracodorsal artery and utilises the overlying skin but not the underlying LD muscle. The TDAP flap therefore shares the benefits of long pedicle length and broad large surface area, yet has the additional advantages of reduced thickness and decreased morbidity when comparison is made to the LD flap[33].

As described previously, the terminal branches of the thoracodorsal artery become intra-muscular within the Latissimus Dorsi. A single perforator is sufficient to supply a skin paddle of up to 15cm by 25cm[31]. Perforators originating in the vertical branch have a shorter intra-muscular course and are therefore preferred over those derived from the transverse branch. An average of more than three musculocutaneous perforators, predominantly from the vertical branch, have been demonstrated[34, 35, 36]. The thoracodorsal artery may, in fact, supply direct cutaneous perforators before it enters the LD muscle[13] but their use potentially comes at the expense of pedicle length.

Two consistent anatomical landmarks have been described for localising perforators intraoperatively. The first, published by Angrigiani[31], describes the main perforators arising from the vertical branch as it leaves the muscle in the subcutaneous tissue. This point lies 8cm inferior to the axilla in the posterior axillary line, and 2cm medial to the lateral border of LD. The second relates to the bifurcation of the thoracodorsal artery, into the vertical and transverse branches. Heitman et al[34] suggested that all perforators were in close proximity to a point 4cm inferior to the tip of scapula, and 2.5cm medial to the fee border of LD. Perhaps the most useful description is that of Schaverien et al[37] who found the greatest concentration of perforators (> 0.5mm in diameter) 9.5 – 15.4cm from the posterior axillary fold within 4.3 cm of the lateral border of LD. Therefore, siting a skin paddle over this area increases the chance of having a perforator with a diameter >0.5mm. **Figure 3** demonstrates the anatomical location of the perforators derived from the paper by Schaverien et al[37].

The TDAP flap posses many of the qualities that are required for a soft tissue flap in head and neck reconstruction. It provides a large and relatively thin hairless skin paddle, and has a mean pedicle length of 15cm[38, 39]. As with the LD, this makes it particularly useful in vessel-depleted necks, where the contra-lateral neck may be used for anastomosis, and in reconstruction of the mid-face, skull base and scalp. The main difference between the TDAP and LD is the volume of soft tissue, the TDAP being considerably thinner. The TDAP has been shown to be a reliable flap by Hamdi et al[40], who in a retrospective review of 90 TDAP flaps for breast reconstruction report only one case of flap loss. Similarly, Lee and Mun[41], report the loss of only one TDAP flap in a review of 31 flaps.

Relative to the radial forearm (RFFF) and Antero-lateral thigh (ALT) free flaps, the TDAP flap, in our experience, is more technically challenging to raise. **Figure 4** shows a TDAP flap being raised with a large skin paddle and demonstrates the length of pedicle achievable. The intra-muscular dissection can be difficult and unforgiving due to the relatively small perforators and propensity for multiple branches. However, the resultant scar below the posterior axillary fold is easily hidden and donor site morbidity is reported as being minimal when compared to the RFFF[42]. Importantly, the TDAP flap spares both the LD muscle and its motor nerve, thereby preserving muscle strength and shoulder function. While some authors[42] have claimed it is possible to harvest the flap in the supine position and therefore facilitate two-team operating, harvesting in a lateral decubitus position is more common but as a result includes a time consuming element.

Tip of Scapula

Swartz et al[43], in what was the first published series of cases where the scapula was used as a donor site for head and neck reconstruction; found that when the tip of scapula was included, its blood supply was tenuous. Deraemaeker et al[44] subsequently identified the angular branch of the thoracodorsal artery as an additional or indeed independent blood supply to the caudal portion of the lateral scapula. Coleman and Sultan[45] consequently described a free flap with the scapular tip and Latissimus Dorsi as a single unit. In addition, they highlighted that use of the angular artery enabled the harvesting of 2 separate bony segments based on 2 separate branches of the subscapular artery, namely the circumflex scapular artery and the angular branch of thoracodorsal. However, it should be noted that up to 8% of patients do not have a subscapular artery; in such instances the circumflex and thoracodorsal arteries arise independently from the axillary artery[46, 47].

As previously mentioned Deraemaeker et al[44] identified the angular branch as an independent blood supply to the tip of scapula. Seitz et al[48] reported the mean combined pedicle length of the angular branch and thoracodorsal artery as being 14.8cm. This increases to 16.7cm when the subscapular artery is included. Chepeha et al[49] reported a mean length of bone in addition to pedicle as an impressive 27cm (range 23 – 32cm).

Regarding the amount of bone that can be safely harvested on the angular branch, Yoo et al[50] have reported the average length as 6.2cm with the longest segment measuring 8cm in their series. This compares similarly to the average length of 5.2cm (range 2.5 – 9cm) described by Chepeha et al[49]. Seneviratne et al[51], in 81 cadaveric dissections, found that the angular branch can supply up to 20cm of bone form both the medial and lateral scapula, however this has not yet been reproduced in a clinical series.

The Tip of Scapula can be harvested as a stand alone myo-osseous flap (with terres major), or as part of a chimeric flap. Its application as part of a chimeric flap will be discussed further below. Relative to other composite bone flaps, this flap has a number of advantages; namely a long pedicle, independently mobile chimeric options, and the scope for a variety of osseous shapes (albeit limited in terms of scapula thickness). However, the volume of bone available is limited by comparison to the iliac crest and fibula. The Tip of Scapula has been described for reconstruction of short posterior mandibular defects, including those of the angle (Brown Class 1) [49, 52,53, 54]. Its utility is exemplified in both the description of a condyle-ramus unit by Yoo et al[49] and its usage for reconstruction of 39 maxillary defects by Miles & Gilbert[55].

Figure 6 demonstrates a Tip of Scapula flap being used for a Brown Class V maxillary defect requiring reconstruction of the orbit. In this case the flap was positioned vertically.

Chimeric Flaps

As previously mentioned, one of the greatest advantages of the thoracodorsal system is versatility of the chimeric flap options on offer. In addition, and owing to the fact that the circumflex scapular and thoracodorsal arteries are commonly derived from the subscapular artery, both scapular and parascapular flaps can be incorporated to form even reconstructive flexibility. **Figure 5** shows a complex chimeric option based on the TDAP and a composite parascapular flaps. Although not included within this free flap it is also possible to include the TSCAP as a further bony element if required. We have previously published the use of the TDAP-Scap in situations calling for both hard and soft tissue complex reconstruction, often in vessel depleted areas[56]. The subscapular system is unique in its ability to address all of the reconstructive requirements in these cases. A long pedicle, along with independently mobile tissues can often negate the need for harvesting a second free flap.

While the need for 2 flaps to reconstruct a defect is rare, those defects that do require more than one flap are challenging. Wei et al[57] suggested that composite resections not adequately reconstructed with one flap, for example large intra-oral defects and complex 3 dimensional defects are some of those that may require chimeric flaps, the alternative being two separate free flaps. In our practice we have found that separate free flaps have an increased risk of failure and it would be our preference to utilise the subscapular system in these situations. **Figure 6** shows a photographic series of a case of complex mandibular reconstruction with the LD-TSCAP chimeric flap for an extensive through-and-through defect. This series demonstrates the versatility of the soft tissue and length of pedicle reaching the contra-lateral neck.

Uglesic at al[58] were the first group to publish a large series of cases where radical maxillectomy defects were reconstructed using a LD-TSCAP flap (similar to that shown in **Figure 2**). Several other authors have described similar reconstructions[13, 59, 60]. Chepeha et al[49] highlighted the potential benefits of the chimeric TSCAP flap; including a long pedicle, independently mobile soft tissue components, and the 3-dimensional nature of the scapular tip. L'Heureux-Lebeau at al[61], in a retrospective review, reported the outcomes of 16 patients in whom oro-mandibular defects were reconstructed with the LD-TSCAP flap. They reported no flap losses, and concluded that this chimeric reconstruction is both safe and reliable.

Our group[62] previously detailed the use of a LD-TSCAP flap for management of 9 patients following midface resections, of which 8 were extended maxillectomies (Brown Class 4) [63] with orbital exenteration. While there were no micro-vascular failures in this series, the bony component of one flap proved not to have a viable blood supply was ultimately debrided.

Midface Reconstruction

The thoracodorsal system, with its variety of free flaps and pedicle length, is useful is in maxillary/midface reconstruction. The 3-dimensional nature of these defects asks unique questions of the reconstructive surgeon. Not only may vascularised bone be required to replace the palate, facial profile or orbital wall, but soft tissue may also be required to line the oral and/or nasal cavities, as well as cutaneous defects. While **Figure 7** demonstrates how the TSCAP can be positioned in the vertical plane to reconstruct orbital defects, the TSCAP can also be positioned in the horizontal plane to reconstruct low-level defects (Brown Class 2 or 3). The TSCAP is particularly suited to this reconstruction as shown by Pagedar et al[64] who found remarkable similarities in both size and shape in a study based on CT imaging. However, as mentioned before, the thickness of bone is not ideal for endosseous implants and as such the potential for complete oral rehabilitation is compromised. Miles and Gilbert[55] reported a 46% complication rate in their series of 39 TSCAP flaps used to reconstruct maxillectomy defects, although most were relatively minor. Perhaps the most note-worthy complications were firstly that 36% of patients had an inadequately reconstructed gingivo-buccal sulcus (further reducing the chance of oral rehabilitation) and that 21% developed a palatal fistula (albeit half of which closed spontaneously).

While the traditional scapula flap, based on the circumflex scapular artery, has been used for maxillary reconstruction, it is limited by short pedicle length and more frequent necessity for vein grafts, and the inherent increase risk of microvascular compromise. For this reason, if a decision is made to utilise the scapula donor site for a patient requiring midface reconstruction, it is our preference to harvest the Tip of Scapula.

Mandibular Reconstruction

Use of the fibula, iliac crest, scapula, and composite radial free flaps have been well described for mandibular reconstruction[65]. The Tip of Scapula, notwithstanding the decreased ability to place endosseous implants[66], and a lack of bone length, has some potential advantages. Its unique shape is ideal for defects of the mandibular angle and for those defects that extend into the ramus or body (Brown Class I). This shape may obviate the need for an osteotomy. In addition, this flap should also be considered where a short linear segment is required in combination with a large soft tissue defect. Yoo et al[50], describe the successful reconstruction of a condyle-ramus unit where the fibrous tip of scapula was used to replace the condylar head. As discussed previously for midface reconstruction, the pedicle length is advantageous, particularly in cases where the contra-lateral or inferior neck is used for anastomosis. However the TSCAP is not suitable for mandibular defects greater than 10cm in length, and in those requiring osteotomies.

For mandibular reconstruction, it is our practice to reserve the Tip of Scapula for predominantly Class I, and some Class II defects that require either contralateral neck access or ipsilateral transverse cervical vessels in patients not suitable for fibula flap harvest (e.g. peripheral vascular disease). In addition to this, if there is an associated complex soft tissue defect(s) then the use of the scapula tip is favoured above all other flaps[54].

Donor Site Morbidity

While some of the advantages of the Thoracodorsal system of free flaps have been described in this paper, it is not without its problems. Harvesting these flaps simultaneously with tumour ablation is difficult, and consequent patient repositioning inevitably results in increased operative time. Care must be taken to stabilise the contralateral shoulder while bringing the patient into the lateral decubitus position, as injury to the brachial plexus can occur[67].

However, it seems that relative to other donor sites, there is less morbidity. Bach et al[42] compared the cosmetic results of radial forearm free flaps with those of Thoracodorsal artery perforator flaps (TDAP) using three scar-scoring systems, and found greater patient satisfaction with the TDAP scar. In addition, they demonstrated minimal donor site morbidity associated with the TDAP donor site. Of note, they also state that while flap-harvesting time was greater for the TDAP flap, it was never longer than the cancer resection time. This is relevant, given that they harvest the TDAP in a supine position concurrent with tumour resection.

We have found that, as a result of taking terres major with tip of scapula flaps, a discreet hollowing/deformity of the skin can result. This, however, does not seem to be of concern to patients.

Hamdi et al[68], looked at shoulder function post TDAP flap harvesting and demonstrated that sparing of the motor nerve to Latissimus Dorsi preserves muscle strength and a full range of shoulder movement. In addition, they report that the absence of dead space in the axilla, and preservation of Latissimus Dorsi function are associated with decreased incidence of seroma.

Miles and Gilbert[55], in a retrospective review of 39 post-maxillectomy patients reconstructed with scapular tip free flaps, reported that mild post-operative seroma was a common occurrence, but that less than 8% required intervention. The stated further that shoulder morbidity was not a significant problem. Chepeha at al[49] reported on 21 patients reconstructed with a scapular tip free flap, and found that donor site complication rates were low. Two of their 21 patients had minor early complications (haematoma, and wound breakdown). Again, they found no significant shoulder dysfunction.

Shoulder morbidity may be minimised by suturing the remaining serratus anterior to the remaining scapula in combination with fastidious post-operative physiotherapy[19, 69]. Ferrari et al[70], in a paper looking solely at donor site morbidity, found a very low rate of shoulder morbidity, which did not interfere with activities of daily living, in patients with scapular tip free flaps. In addition, they reported a mean time to ambulation of 2.7 days. Other authors, albeit reporting on morbidity following para-scapular and scapular free flap harvesting, described similar results. Roll et al[71], in a series of 20 patients reconstructed with a parascapular flap, reported that 3 had limited shoulder function post-operatively. Gibber et al[47], in their previously mentioned retrospective review of 105 patients, reported no post-operative shoulder dysfunction.

Anecdotally, we have found that there is less morbidity associated with flaps harvested from the subscapular system relative to, for example, the iliac crest or fibula. This is significant in elderly patients for whom early mobilisation is hugely important. In our practice this, along with the aforementioned benefit of protection from atherosclerosis, means we often choose this flap in elderly or frail patients.

Discussion

There is no doubt that the advent of microvascular free tissue transfer has allowed the predictable reconstruction of large and complex head and neck defects. There are numerous donor sites available, each with their own advantages and disadvantages. The thoracodorsal system has a range of hard and soft tissue flaps that can be raised independently or as chimeric flaps with independently mobile components. These features in combination with a substantial pedicle length, that predictably negates the need for interpositional grafts or multiple flaps, are the main advantages of the thoracodorsal system. In addition, for patients in whom early post-operative mobility is critical, the thoracodorsal system has obvious advantages relative to the iliac crest[72] and fibula. Further, the thoracodorsal system is particularly useful in patients for whom peripheral vascular disease precludes the use of other donor sites[7]. Finally it is easier, relative to other donor sites, to camouflage the resultant scar[73].

In conclusion, free flaps based on the thoracodorsal system are suited to complex defects requiring extensive soft and hard tissue reconstruction as well as those requiring long pedicle length (e.g. vessel deplete necks). In these complex cases, the use of thoracodorsal system-based free flaps may negate the need for interpositional vein grafts and/or the harvesting a second flap, both of which are factors that add a layer of complexity and are associated with increased potential for complications.

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Figure

Figure 1. Summary of critical aspects of thoracodorsal arterial anatomy relevant to the reconstructive surgeon.

Figure 2. The Latissimus Dorsi and tip of Scapula (LD-TSCAP) chimeric flap. Note the large volume of soft-tissue that is independently mobile from the bone.

Figure 3. Diagram to show where the greatest concentration of perforators >0.5 mm in diameter can be found (dashed yellow circle) when planning the thoracodorsal artery perforator flap (TDAP). The measurements are derived from Schaverien et al[37]. Note that the TDAP flap is predominantly centred over the vertical branch of the thoracodorsal artery.

Figure 4. Intra-operative photograph demonstrating the thoracodorsal artery perforator (TDAP) flap being raised. Note that the large skin paddle and long length of pedicle that can be achieved. Also note the extensive muscular dissection required to raise this flap.

Figure 5. A chimeric flap incorporating the thoracodorsal artery perforator flap and composite parascapular flap. The point at which angular branch takes off from the thoracodorsal artery is labeled to demonstrate that the tip of scapula flap can also be incorporated should the ablative defect require two independent bone flaps (e.g. in combined maxillary and mandibular reconstruction).

Figure 6. Intra-operative series demonstrating the use of the chimeric Latissimus Dorsi and tip of Scapula (LD-TSCAP) flap in complex post radiotherapy mandibular reconstruction. A) Complex through-and-through defect involving skin, bone and oral mucosa. B) Contralateral neck used for anastomotic vessel access. The ruler demonstrates the length of pedicle required. C) The harvested LD-TSCAP flap with independently mobile soft and hard tissue components. D) The flap inset to the defect.

Figure 7. The Tip of Scapula (TSCAP) flap used for midface reconstruction. In this case the bone was positioned cranio-caudally (vertically) to reconstruct a Brown Class V Orbito-maxillary defect. The bone supports both the overlying soft-tissue as well as the orbital contents.

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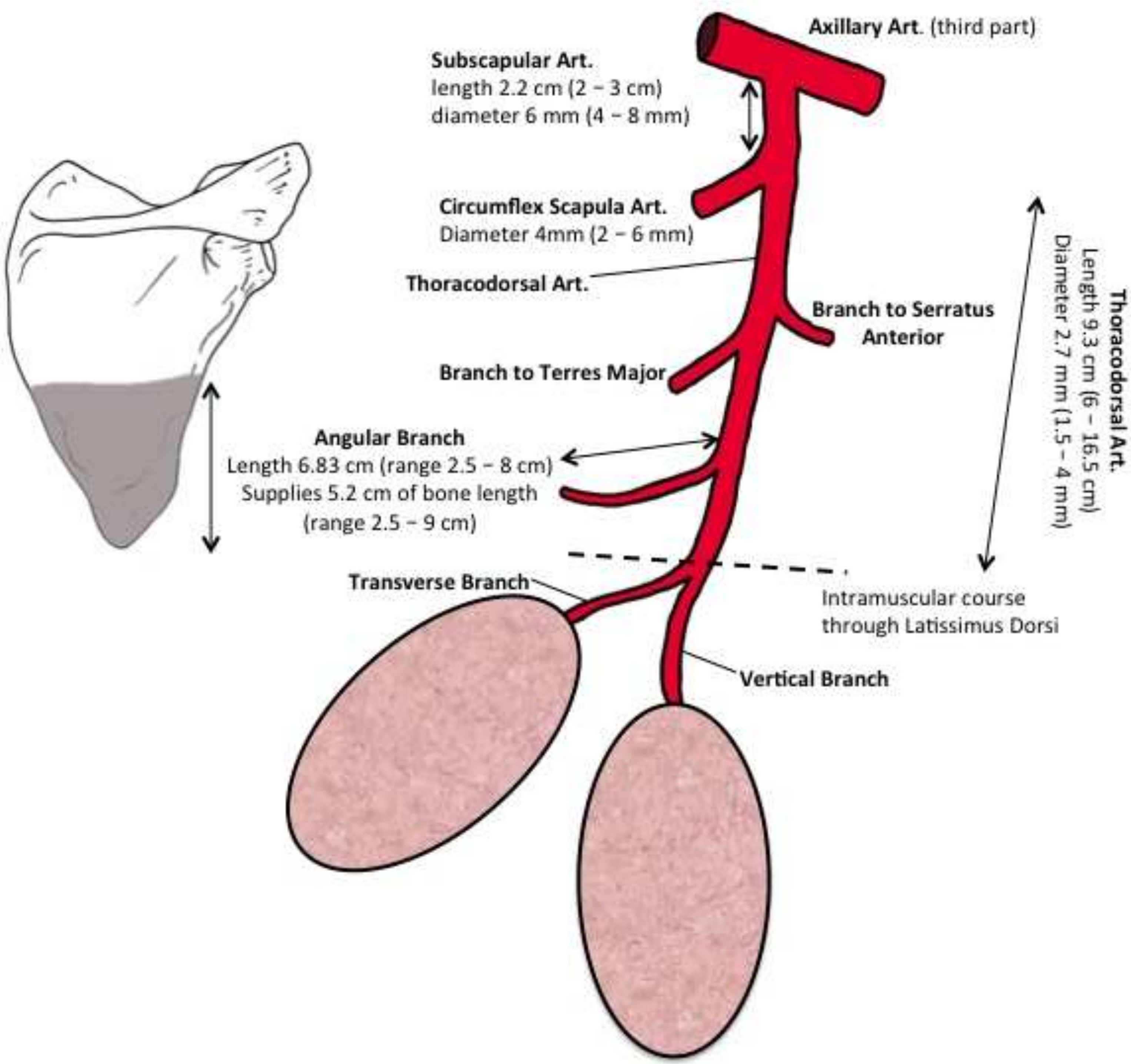

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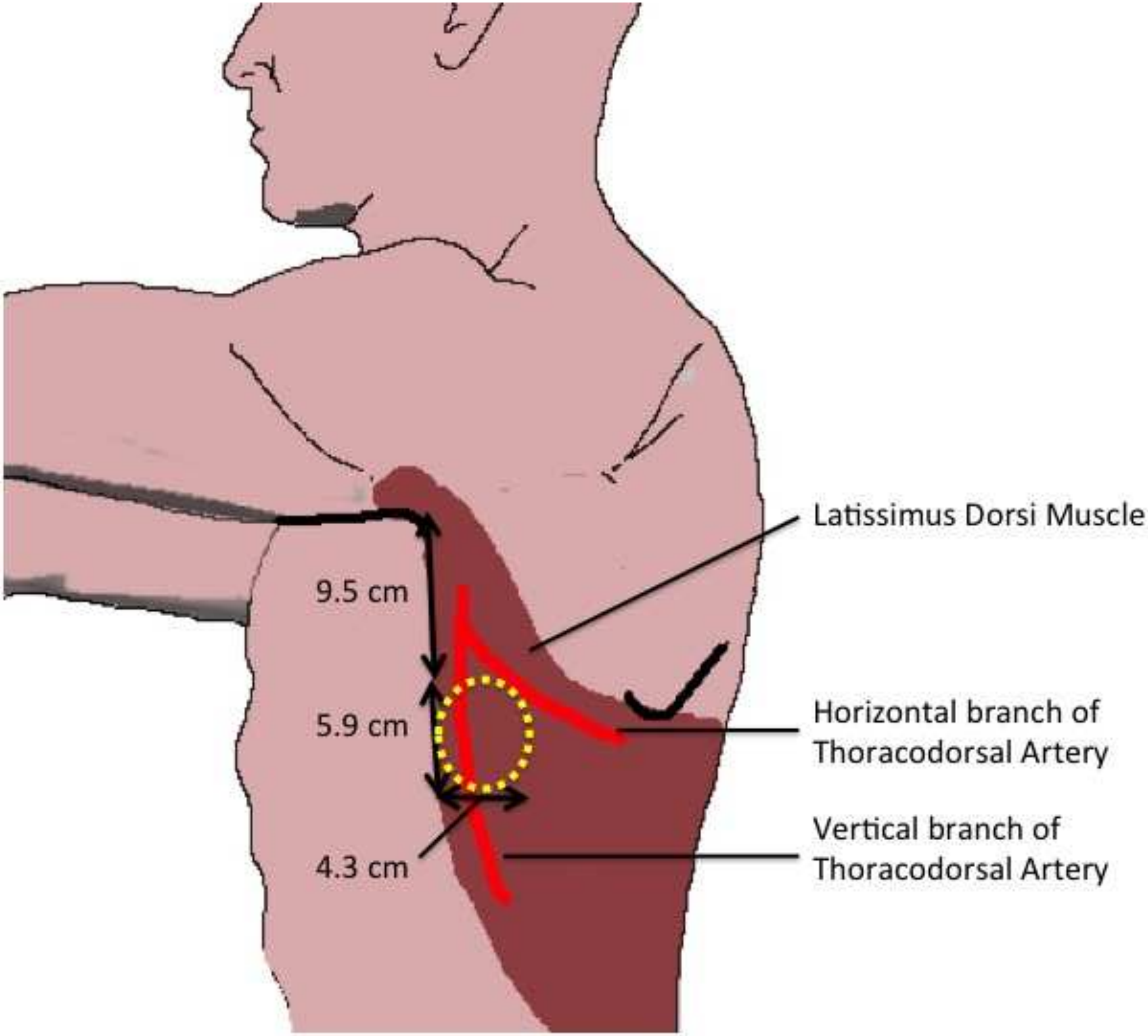

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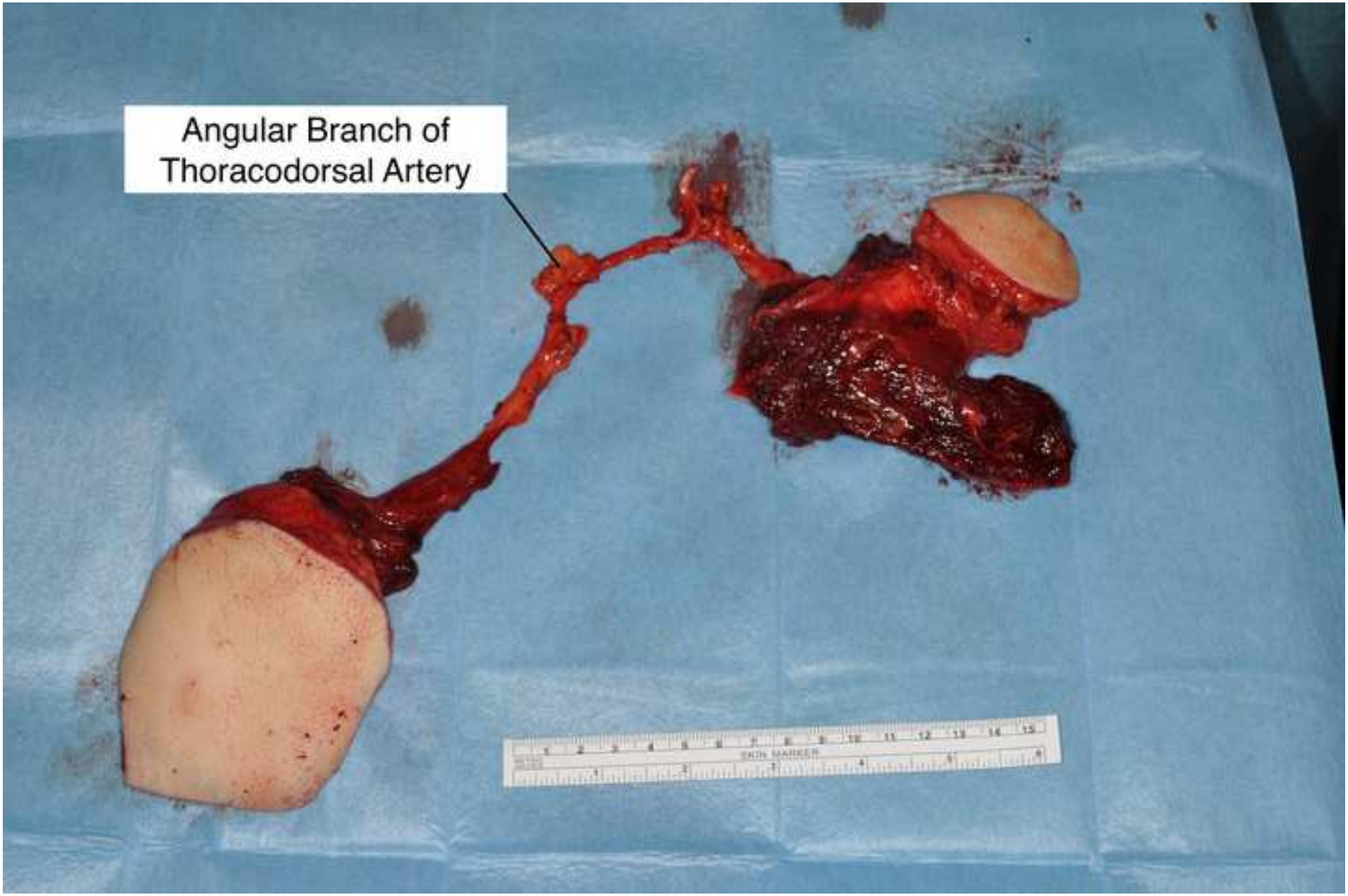

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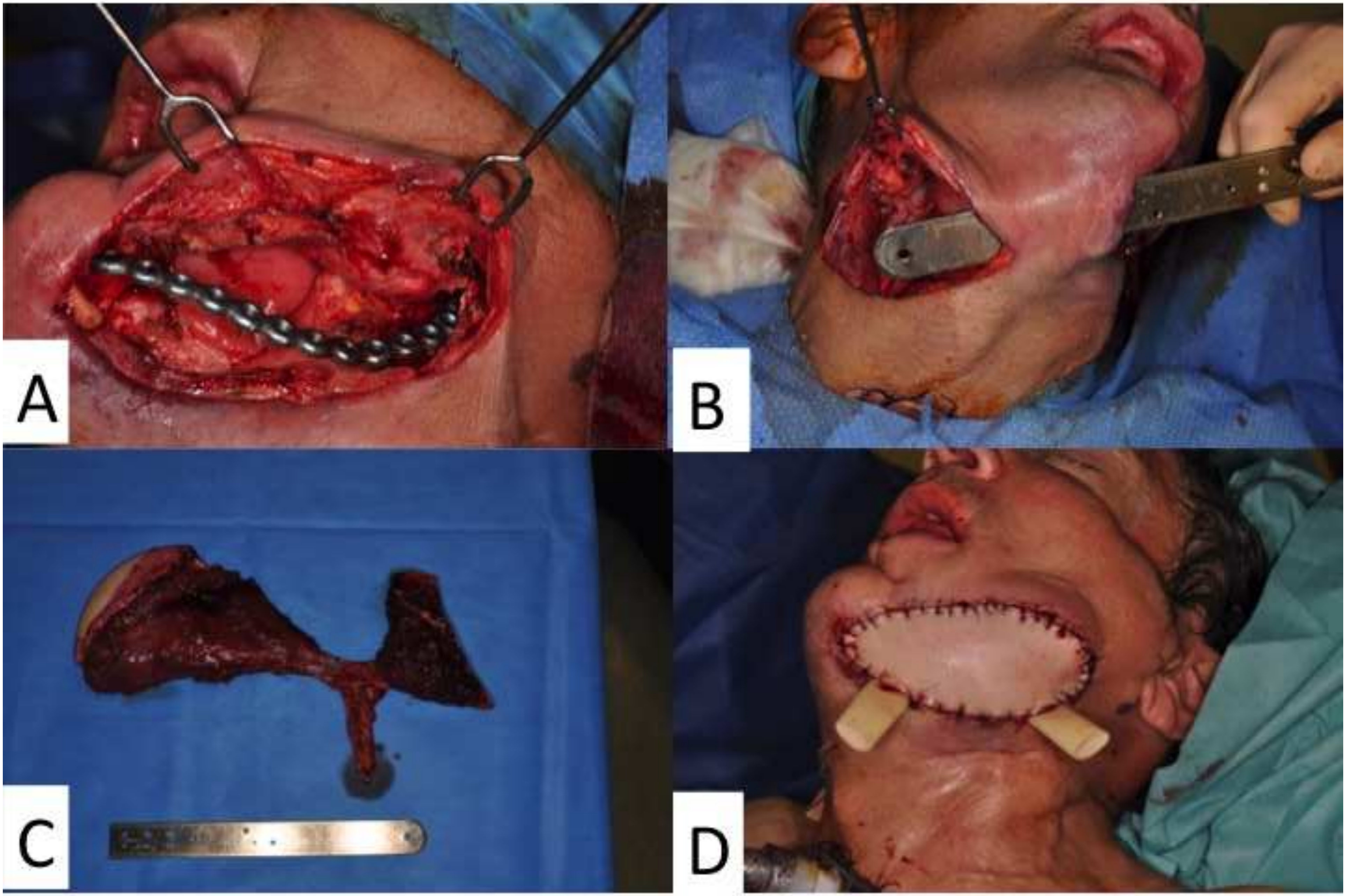

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