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Reconstrução facial complexa baseada em modelos 3D: casos de prelaminação e revisão da literatura

Complex facial reconstruction based on 3D-models: prelamination cases and literature review

ABRIL, 2020

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TÍTULO ~~DISSERTAÇÃO~~/MONOGRAFIA (riscar o que não interessa)

Complex facial reconstruction based on 3D-models: prelamination cases and literature review

ORIENTADOR

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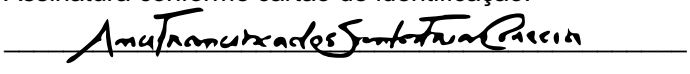

DEDICATÓRIA

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Complex facial reconstruction based on 3D-models: prelamination cases and literature revision

ABSTRACT

Background: There is little literature recalling the combined use of 3D-modeling and prelamination, but the use of 3D-models in the planning of surgeries using free flaps has been vastly described. The purpose of the present study was to also demonstrate the applicability of the combined use of 3D-models and prelaminated free flaps in the correction of complex facial deformities.

Methods: A literature revision was performed in order to find the current applicability of 3D-modeling combined with free flaps and which free flaps were most commonly used in these cases. We also selected two patients with significant facial disfiguration that were submitted to surgeries that included prelamination and 3D-modeling and presented their outcomes.

Results: 3D-modeling is mostly used in the correction of mandibular defects with fibular free flaps. Here we demonstrated the importance of 3D-modeling in surgeries using different types of free flap – prelaminated ones. The two patients selected achieved an aesthetic and morphological improvement that would hardly be obtainable otherwise.

Conclusion: Prelamination used alongside 3D-modeling can be a powerful tool in the correction of diverse facial deformities.

Key-words: Facial reconstruction; prelamination; 3D-modeling.

INTRODUCTION

The face is one of the most important regions of the human body and contains complicated and delicate features that help defining the identity of a person (1). The deformities in this region can have multiple etiologies: oral cancer, burns, infections, osteoradionecrosis, vascular lesions, traumatic injuries and congenital anomalies. There are various methods of reconstruction and it is important to perform a morphologic and dynamic evaluation of the patients in order to find the best one (2).

As computer-based technology evolved, 3D-models became widely used when it comes to facial reconstruction since they enable a more accurate surgery planning. Mandible defects have been successfully fixed with the use of 3D-modeling, being its use described in fracture repair surgeries (3–7) and aesthetic surgeries regarding mandibular features (8–13). The processes of orbital reconstruction (14–17), ear reconstruction (18), zygomatic bone repair (19,20), rhinoplasty (21,22) and nose reconstruction (23,24) have also achieved successful aesthetical results due to 3D-modeling. To emphasize its wide range of applications, it can also be used in female feminization surgeries, where an individual approach is the key (25).

The term prelamination designates a process in which a 3D-structucture – which can be composed of tissues, or tissue engineering products – is engrafted or implanted into a reliable vascular territory without interfering with its blood supply, being transferred to the recipient site 2 to 3 weeks later (26,27). The purpose of prelamination is to reliably transfer the most appropriate tissue from one area of the body to a site in need of reconstruction, obtain the most suitable free flap (28).

Little literature has mentioned the combined use of 3D-modeling and prelamination, but there are studies mentioning the association of 3D-models and free

flaps. Here we describe two successful applications of using 3D-modeling techniques when planning surgeries that involved prelaminated free flaps.

METHODS

We conducted a literature review in order to ascertain the current applicability of 3D-modeling combined with free flaps in reconstructive surgery.

PubMed and Scopus electronic databases were searched for Articles using the following query: ("Face"[Mesh] OR "face"[Text Word] OR "facial"[Text Word]) AND ("Reconstructive Surgical Procedures"[Mesh] OR "Surgery, Plastic"[Mesh] OR reconstructive[Text Word] OR reconstruction[Text Word]) AND ("Imaging, Three-Dimensional"[Mesh] OR 3D[Text Word] OR three-dimensional[Text Word]) AND ("Models, Anatomic"[Mesh] OR model[Text Word] OR modeling[Text Word]) AND ("Free Tissue Flaps"[Mesh] OR free flaps[Text Word]).

We identified 13 articles from PubMed and 33 from Scopus, amounting to a total of 46 titles (Fig. 1). After removing duplicates, we scanned 38 titles and abstracts, selecting 34 for full-analysis. After accessing the full text of the included articles, 11 were excluded. The reasons for exclusion were: reviews (n=3), study not available (n=1), use of grafts and not flaps (n=2) and language issues (n=1). Also, studies with more than 15 years were excluded considering the great technical advances recognized in reconstructive surgery (n=4). Finally, 23 articles were included in the literature review.

We also selected two patients that were treated in our institution who represent suitable examples of innovative prelamination techniques that involved 3D-modeling procedures.

RESULTS AND DISCUSSION

CASE 1

A 27-years-old patient with severe sequelae of thermal burns (55 percent total burn surface area), including ectropium, upper and lower lip retraction and partial nasal loss (Fig. 2), was a candidate for facial transplantation, but as he did not consider it, other options were investigated.

Prelamination was the selected method. The only unburned area in the body of the patient was the left dorsal region, where there is a constant pedicle (parascapular artery and vein). In a first stage, an elective surgery was performed to identify and tag the recipient vessels in the neck (Fig. 3). The prelamination process was then initiated with the drawing of a facial model on the back of the patient. This was based on a 3D-latex model performed at the Faculty of Arts as a print of the patient's face (Fig. 3), which allowed us to calculate distances and estimate the length of the vascular pedicles. In this phase, partial delay of the flap was performed, and a nose and lips were drawn and open inside the flap, with placement of biomaterials (porous polyethylene implant) and grafts (Fig. 4). After three months, the flap was transferred and microvascular anastomoses between the subscapular vessels and the recipient vessels in the neck were made (Fig. 4). Revision surgeries were performed, including placement of costal cartilage for nasal shape improvement. However, this did not give enough support for alar rim and columellar reconstruction, so a silicone model was fabricated for that purpose and to avoid airway collapse and nostril occlusion.

From 2012 (the year of the incident) to 2019, the patient has gained better feeding and mouth opening capacity, more effective breathing with more permeable areas and more robust eye protection, which translated into an extremely important functional gain. The aesthetic result has also experienced some improvement (Fig. 2).

CASE 2

A 27-year-old man suffered a motor vehicle accident and presented an almost complete amputation of the left auricle and traumatized temporal skin and fascia (Fig. 5) (29) – this is a senior authors' case. He was not a candidate for traditional repair techniques because of an abrasive injury that reached preauricular and retroauricular skin. A 3D-printed ear made of silicone was developed based on the patient's CT-scan of the contralateral ear and used for intraoperative molding of the future reconstruction. A porous polyethylene implant was considered, however local flap coverage such as temporoparietal fascia flap was not available in this case due to initial damage to the surrounding tissues. Consequently, a prelaminated radial forearm free flap was selected for reconstruction with prolonged prelamination time and surgical delay (three months). Firstly, a subdermal pouch was dissected on the anterior aspect of the left forearm along the projection of the radial artery for placement of a porous polyethylene implant (Medpor ®) that was inserted subdermally (Fig. 6). After a two-month period of integration and neovascularization of the added tissue, the prelaminated flap was transferred (Fig. 7). Flap reinnervation was performed by direct coaption of the great auricular nerve to the lateral antebrachial cutaneous nerve. The flap fully survived and there were no complications in the early postoperative period. Revision surgeries were performed. In three to six months, the patient returned to normal ranges in terms of warmth and cold and recovered the discriminative facial sensibility. After one year, the auricular reconstruction was intact and satisfactory aesthetic results were achieved. Four years after the intervention, the patient already uses short hair and is extremely satisfied with his new ear (Fig. 5).

3D-MODELING AND FREE FLAPS

The combination of 3D-modeling and free flaps has been described in reconstructive surgeries, being more commonly used in maxillary reconstruction (30–37), orbital defects reconstruction (32,33) and mandibular reconstruction (35,38–50). Moreover, reconstructive surgeries regarding Parry-Romberg syndrome and Treacher Collins syndrome have also made use of this combined tool (51,52). Fibular free flaps were the most commonly used for the correction of bony defects, but the use of a thoracodorsal scapula composite free flap (30), vascularized iliac bone combined with a superficial inferior epigastric artery flap (37), iliac bone free flap (50), anterolateral thigh dermal adipofascial flap (51) and temporoparietal galeal flap (52) were also described (Table 1).

Here we present two different free flaps obtained by prelamination: a prelaminated parascapular free flap and a prelaminated radial forearm free flap. They were used in reconstructive surgeries concerning burn injuries and ear reconstruction, respectively. The use of 3D-modeling and free flaps concerning these etiologies is a new approach of this tool.

Burn injuries can demand challenging 3D-reconstructions. When it comes to reconstruction options that can be performed in patients with severe burns, skin grafts are often not used because of poor color matching and secondary contracture and local flaps are rarely obtainable in large burns (28). Therefore, when analyzing reconstructive options in burn patients it may be necessary to resort to techniques that optimize the resources. Facial transplant surgery is an option to be considered in these cases since it presents better aesthetic results and is usually a one-time surgery. However, the requirement of lifelong immunosuppressive therapy, which can bring a lot of nefarious complications, such as increased incidence of malignancies, infections and end-organ toxicity (53), made the patient described in case 1 refuse this

method. Prelamination is among the most effective mechanisms available for approximating aesthetic reconstructive outcomes using autologous tissue (54) and at the end, the patient was submitted to this technique, allowing the best site donor tissue to be used. When selecting the free-tissue transfer donor site, since the two most commonly ones used to replace facial subunits – the radial forearm and temporoparietal fascia flaps – were compromised, other sites had to be explored (55). The parascapular tissue on the left dorsal region was intact, and since the parascapular tissue has a constant pedicle, it was the area selected for the prelamination. Here the latex 3D-model was of extreme importance because it allowed us to calculate distances to perform anastomoses, plan the flap size and prelamination zones, therefore programming a much more efficient and personalized surgery.

When it comes to ear reconstruction, creating an ear form from costal cartilage is the gold standard technique (56), but it is quite demanding and does not have the same elastic properties as ear cartilage. In case 2, we “printed” a silicone 3D-model of the contralateral ear, based on the patient’s CT-scan, and it was used for intraoperative molding of the future reconstruction. At the end, the prelaminated radial forearm flap integrated a personalized polyethylene implant of an ear. This allowed us to obtain a symmetrical aesthetical result.

Nowadays, reconstructive surgery can make use of techniques that allow us to manage complex cases, achieving very good aesthetic and funcional results. Since the facial anatomy is crucial for the patient’s identity and 3D-modeling allows an individual approach, it is easy to understand its extreme importance when it comes to reconstruction of craniofacial defects. 3D-Modeling has been used for a more efficient planning in surgeries recalling free flaps and is more oftenly used in mandibular reconstruction with fibular flee flaps. Although its use in the planning of prelamination

surgeries or in the customization of biomaterials that integrate prelaminated flaps hasn't been, to our knowledge, described in literature, here we verified its applicability. Both patients were complex cases of different etiologies – burn injuries and trauma – and benefited from the use of both prelamination and 3D-modeling, achieving good aesthetic and morphologic results.

CONCLUSIONS

The craniofacial region is one of the most complex in the human body and is of great functional and aesthetic importance, making its reconstruction challenging.

A 3D-modeling approach allows a custom-made reconstruction, being, therefore, extremely important for the aesthetic appearance conservation. On the other hand, prelamination allows the most suitable tissue to be transferred from one area of the body to a site in need of reconstruction. Therefore, prelamination and 3D-models can be used together as a powerful tool in order to achieve personalized 3D-reconstructions using the most appropriate free flap.

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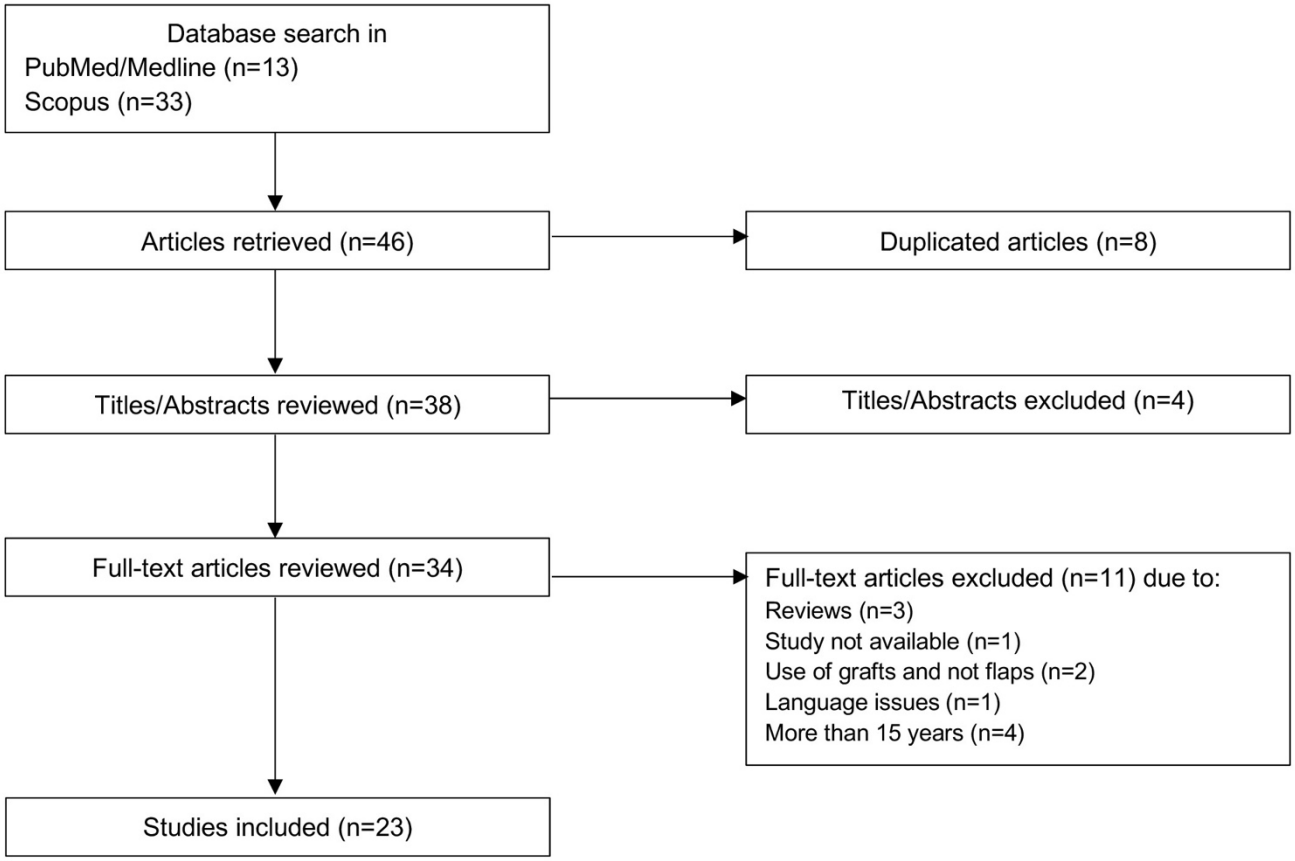


Fig. 1

Fig. 2 A

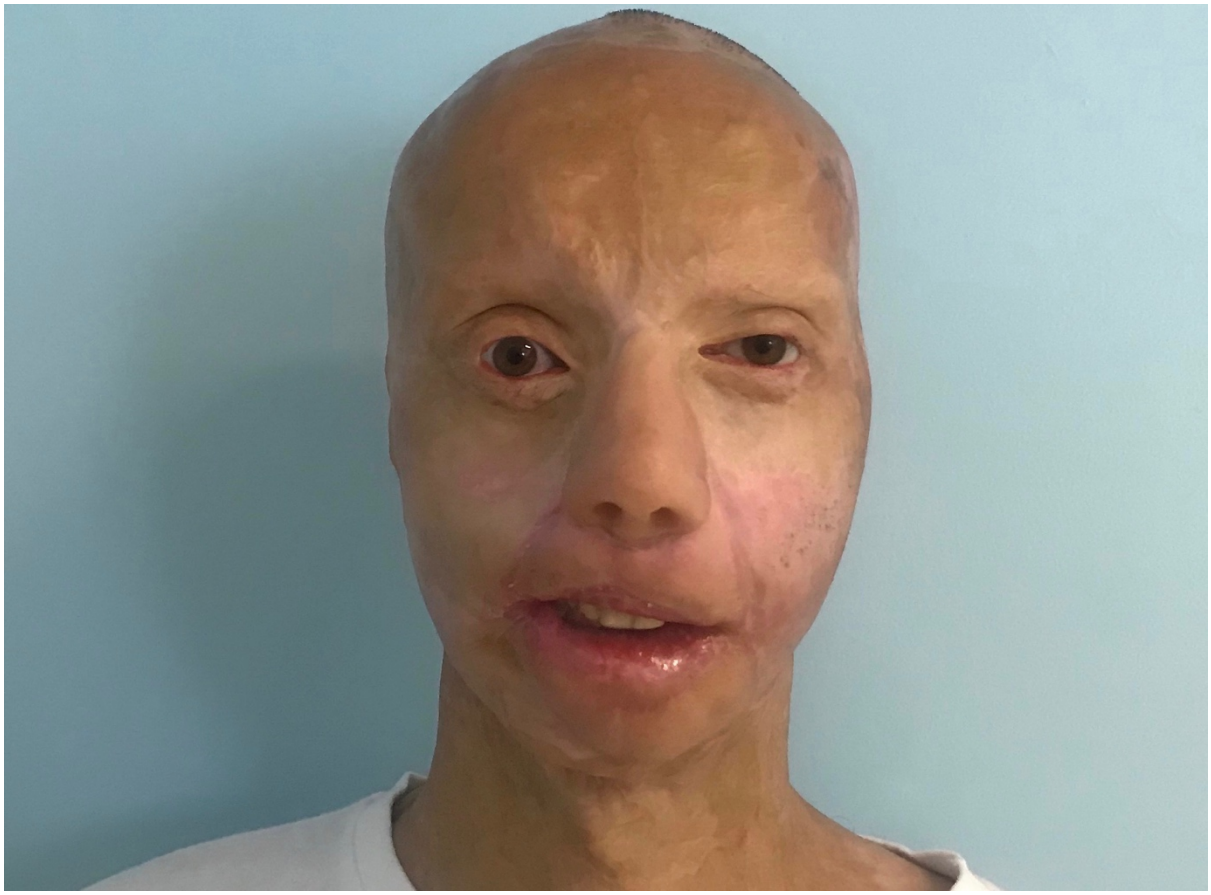
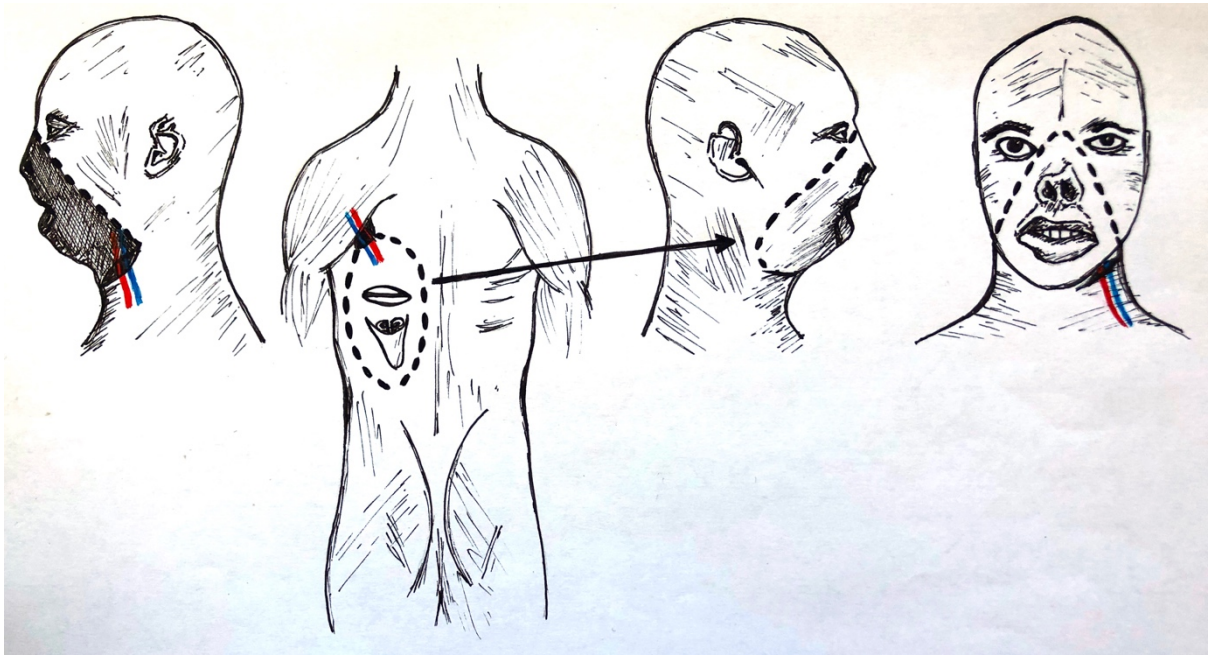


Fig. 2 B

Fig. 3 A

Fig. 3 B



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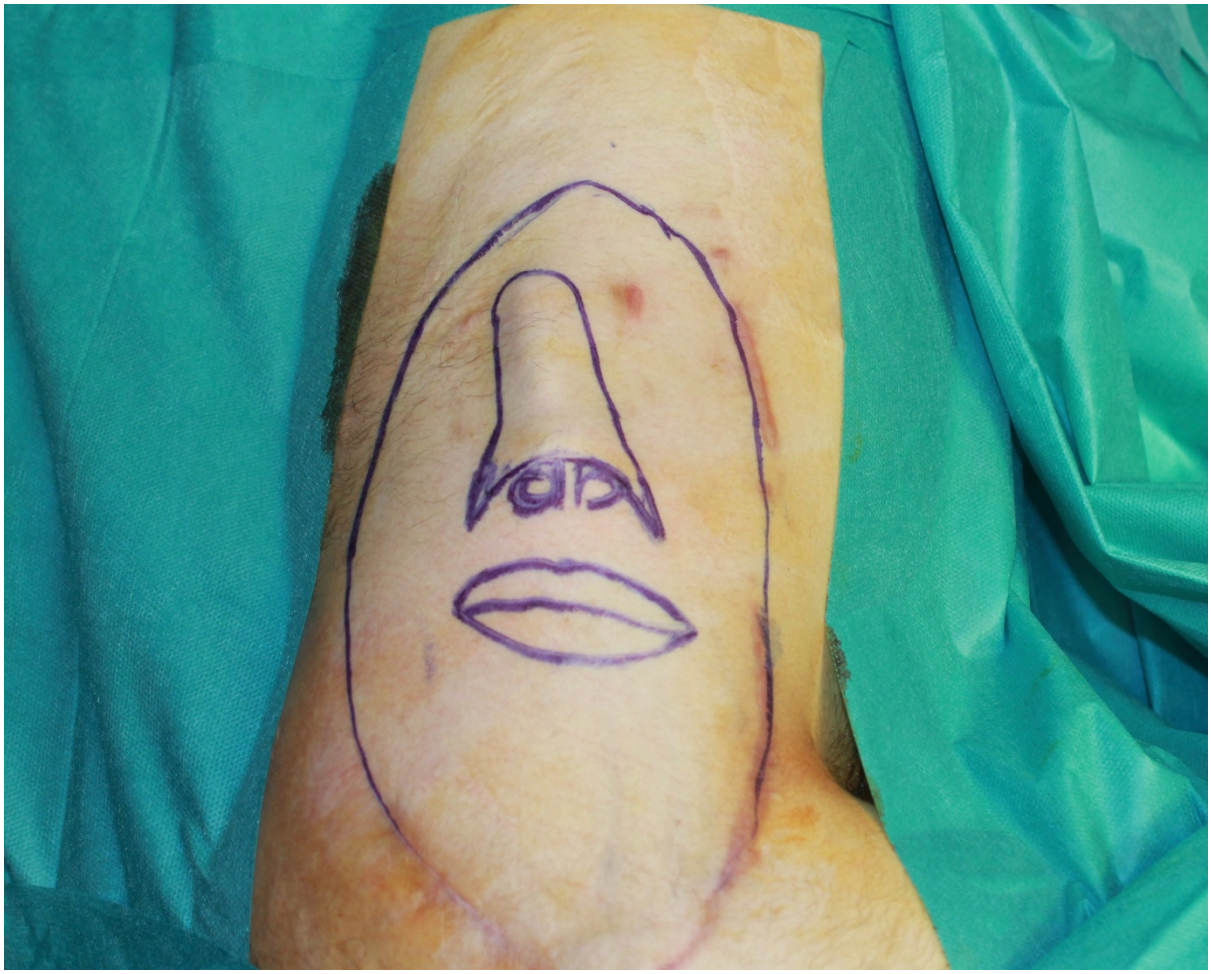

Fig. 4 A

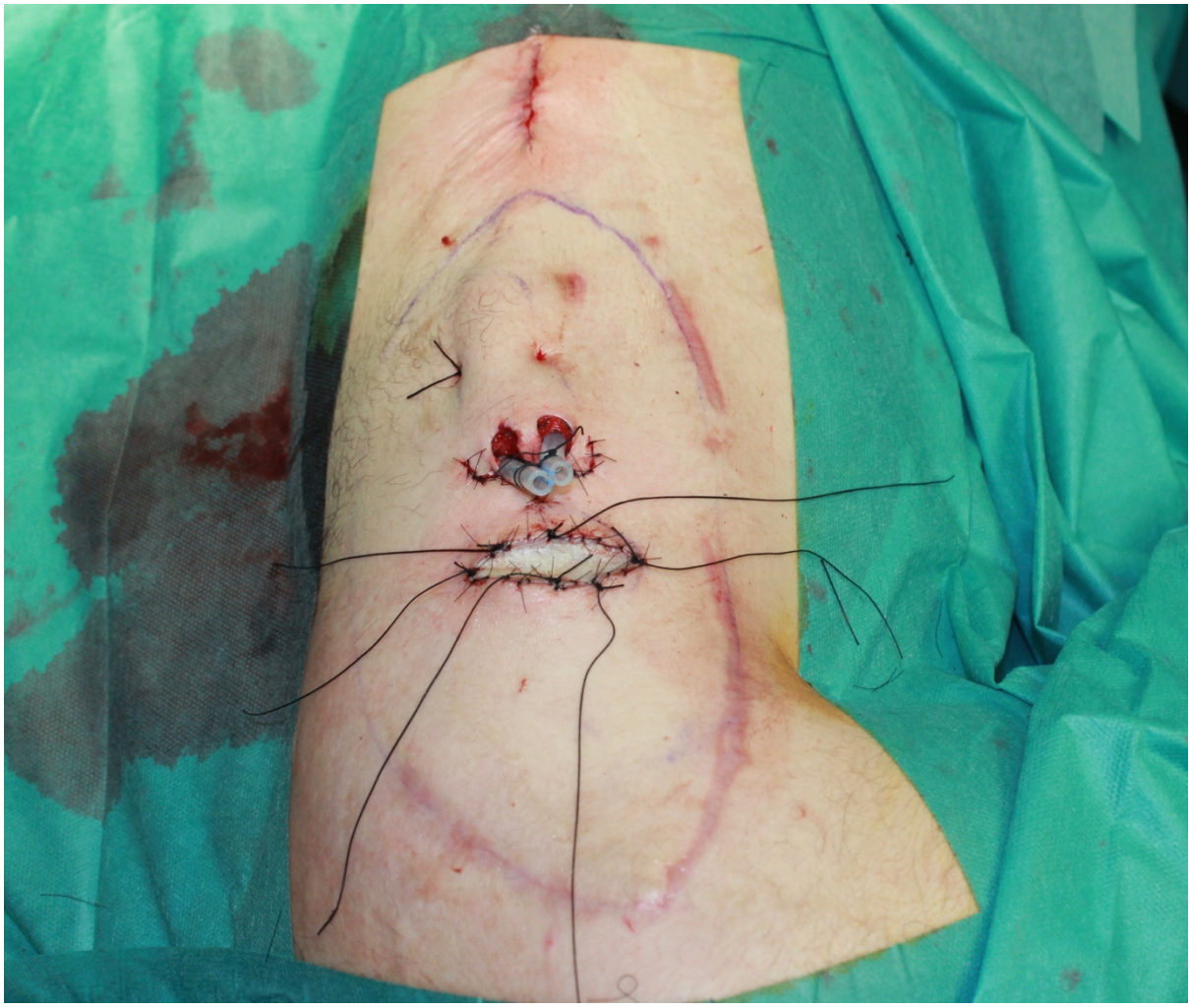

Fig. 4 B

Fig. 4 C

Fig. 4 D

Fig. 5 A

Fig. 5 B

Fig. 5 C

Fig. 5 D

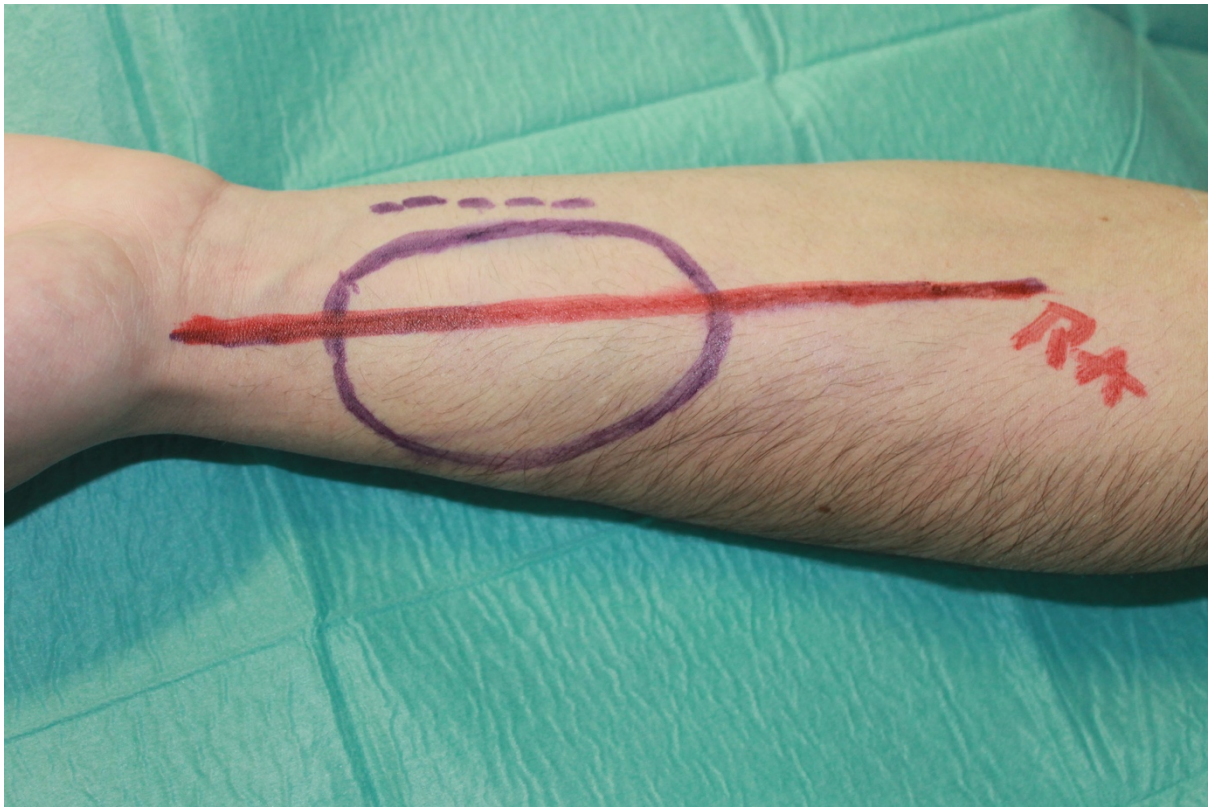

Fig. 6 A

Fig. 6 B

Fig. 6 C

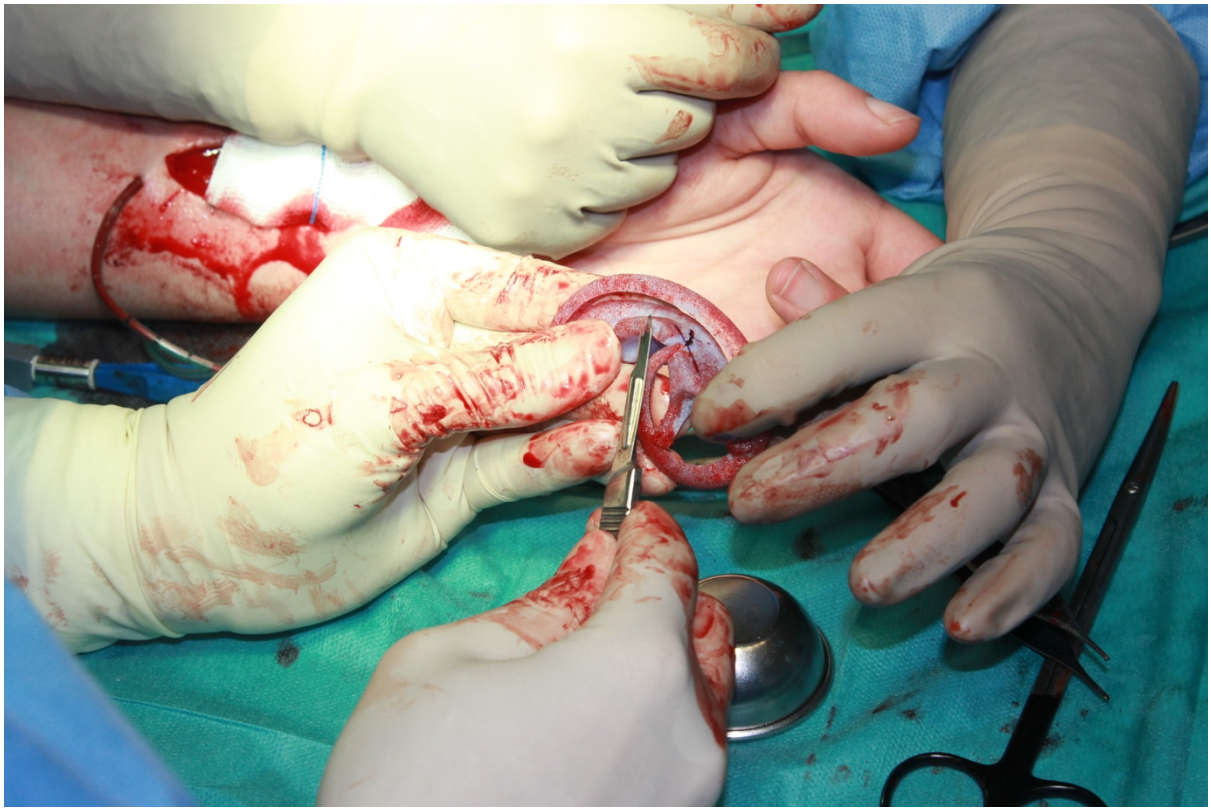

Fig. 6 D

Fig. 6 E

Fig. 6 F

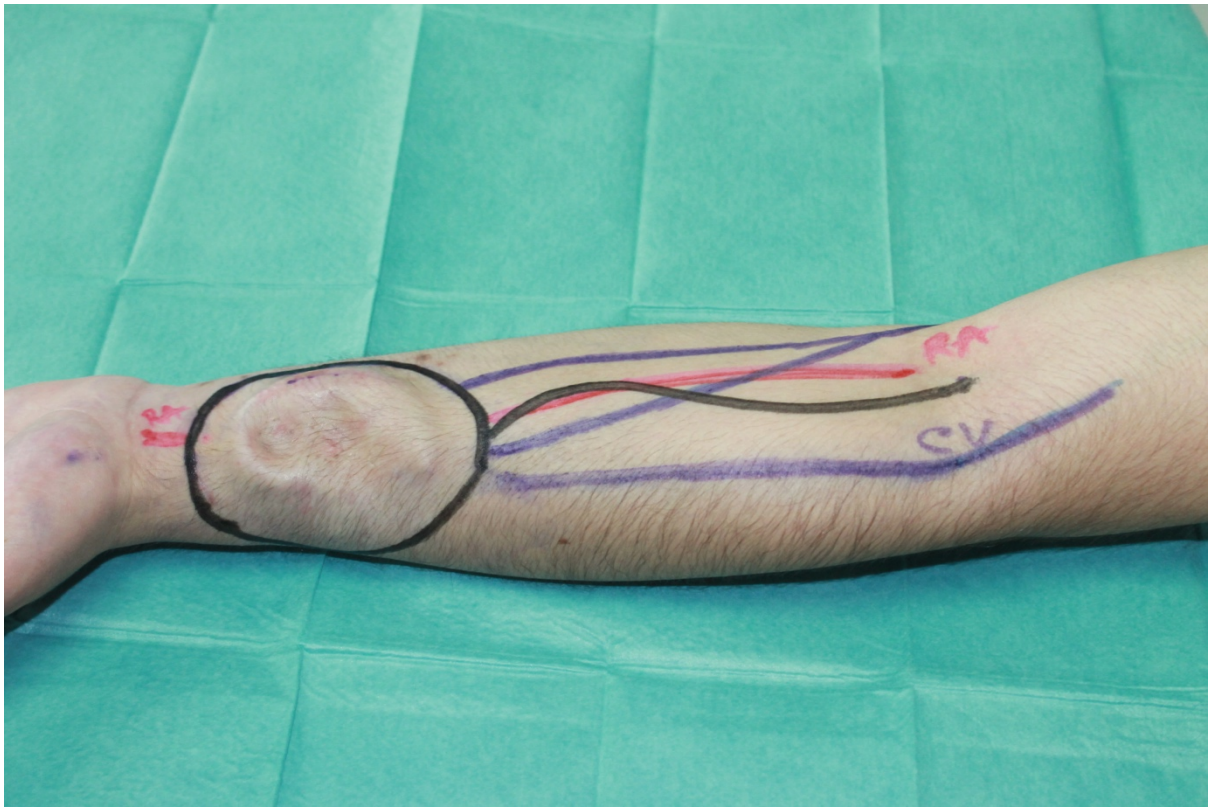

Fig. 7 A

Fig. 7 B

Fig. 7 C

Author, year	Application	Type of free flap
Modest, 2017	Maxillary reconstruction	Thoracodorsal scapula composite free flap
Jędrzejewski, 2012	Maxillary reconstruction	Fibular free flap
Fu, 2017	Orbitomaxillary reconstruction	Fibular free flap
Zhu, 2020	Orbitomaxillary reconstruction	Fibular free flap
Rohner, 2012	Maxillary reconstruction	Fibular free flap
Rodr, 2012	Maxillary and mandibular reconstruction	Fibular free flap
He, 2009	Maxillary reconstruction	Fibular free flap
Hu, 2007	Palatomaxillary reconstruction	Vascularized iliac bone combined with a superficial inferior epigastric artery flap
Jacek, 2018	Mandibular reconstruction	Fibular free flap
Ciocca, 2012	Mandibular reconstruction	Fibular free flap
Katsuragi, 2011	Mandibular reconstruction	Fibular free flap
Roser, 2010	Mandibular reconstruction	Fibular free flap
Cornelius, 2015	Mandibular reconstruction	Fibular free flap
Mottini, 2016	Mandibular reconstruction	Fibular free flap
Kadowaki, 2017	Mandibular reconstruction	Fibular free flap
Iglesias-Martín, 2018	Mandibular reconstruction	Fibular free flap
Arce, 2018	Mandibular reconstruction	Fibular free flap
Lee, 2018	Mandibular reconstruction	Fibular free flap
Wang, 2013	Mandibular reconstruction	Fibular free flap
Weitz, 2018	Mandibular reconstruction	Fibular free flap
Mazzoni, 2013	Mandibular reconstruction	Fibular free flap and Iliac bone free flap
Chai, 2015	Parry-Romberg syndrome treatment	Anterolateral thigh dermal adipofascial flap
Herlin, 2013	Treacher Collins syndrome midface reconstruction	Temporoparietal galeal flap

LEGENDS

Fig.1: Flowchart of the literature review.

Fig. 2: 27-years-old patient with severe sequelae of thermal burns including ectropium, upper and lower lip retraction and partial nasal loss. (A)- Preoperative frontal view. (B)- Postoperative frontal view with the patient using a silicone prothesis for the nose.

Fig. 3: (A)- 3D latex model. (B)- Facial artery and vein identified on the left side of the neck. (C)- Drawn scheme of the prelamination steps.

Fig. 4: (A)- Drawing of facial model on the back of the patient. (B)- Opened nose and lips inside the flap, with placement of biomaterials and grafts. (C and D)- Flap before and after transfer.

Fig. 5: 27-years-old patient with a posttraumatic left ear amputation. Preoperative views (after healing): (A)- Frontal view. (B)- Oblique view. Postoperative views (result after 4 years): (C)- Oblique view. (D)- Lateral view.

Fig. 6: First surgery: (A)- Flap markings. (B)- Pocket planning (C)- A “printed” ear made of silicone based on the patient's CT-scan of the contralateral ear was used for intraoperative comparation and molding of the future reconstruction, (D and E)- The implant was trimmed to a desired shape and inserted into the pocket (F) Immediate aspect after closure and placement of two suction drains.

Fig. 7: Second surgery (A)- Flap markings. (B and C)- Intraoperative images of the flap before and after insertion.

Table 1: Literature review findings: the applicability of 3D-modeling in reconstructive surgeries using free flaps and the type of free flaps chosen.

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Letter to the Editor	No abstract	< 4 images	No references allowed	Up to 500 words
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CONTENTS

MANUSCRIPT FORMAT

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Original Research	Up to 300 words	3-5	No limit	Up to 45 references	Up to 4500 words
Letter to the Editor	No abstract	3-5	No more than 3 images	No references allowed	Up to 500 words
Case Reports	*Case Reports are NOT accepted for publication*				

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