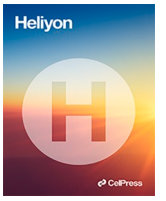
Heliyon 10 (2024) e34613

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

Dovetailing skin incision design of radial forearm free flap for forearm wound closure and maxillofacial reconstruction

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ARTICLE INFO

Keywords:
RFFF
Dovetail
Skin graft
Wound closure
Complication
Abdomen

ABSTRACT

Object: This study aimed to examine the feasibility of the dovetailing skin incision design of radial forearm free flap (RFFF) for closing forearm wounds and performing maxillofacial reconstruction.
Method: A total of 27 patients were divided into two groups. In the dovetail group (n = 16), forearm wounds were closed primarily and maxillofacial defects were reconstructed by dovetail RFFF. In the conventional group (n = 11), forearm wounds were closed by skin grafts from the abdomen or mattress suturing, and maxillofacial defects were reconstructed by conventional RFFF. Information on the healing time of the forearm wound, length of postsurgical hospitalization, esthetic assessments, and complications associated with the forearm wound and the maxillofacial region was collected at least 6 months postoperatively.
Result: The average size of the flap in the dovetail group was smaller than that in the conventional group ($p = 0.134$), and average healing time of the forearm wound in dovetail group was significantly shorter than that in conventional group ($p = 0.000$). Comparing with the conventional group, there were more cases in the dovetail group demonstrating decreased sensitivity ($p = 1.000$). Esthetic assessments of forearm wound and maxillofacial reconstructions in the dovetail group were significantly higher than that in the conventional group ($p = 0.000$).
Conclusion: Closure of forearm wounds and maxillofacial defects using dovetail design was found to be a feasible alternative to the conventional design.

1. Introduction

The radial forearm free flap (RFFF) was originally developed in China in the 1980s [1]. Because of features, such as relative thinness, flexibility, reliable anatomy, and potential sensory recovery [2], RFFFs have been widely used in maxillofacial reconstruction. While alternative free flaps have been developed, RFFF remains one of the main flaps reconstructing maxillofacial defects [3,4].

To meet the requirements of maxillofacial reconstruction, the RFFF has undergone various modifications [3,4]. However, these modifications have always been targeted towards the reconstruction of a specific organ, such as the oral cavity [5] or the urinary

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https://doi.org/10.1016/j.heliyon.2024.e34613
Received 22 March 2024; Received in revised form 25 May 2024; Accepted 12 July 2024
Available online 14 July 2024

organs [6]. Only a small number of modifications of the RFFF have been proposed for the closure of forearm wounds. While some techniques have been attempted, a perfect way to close forearm wounds and reconstruct maxillofacial defects remains unknown [5,7,8]. Using skin graft from the abdomen remains one of the main techniques for repairing forearm wound after RFFF harvesting [9]. However, this conventional technique has some disadvantages, such as uncertain forearm wound healing [10] and a wound in the abdomen.

A technique was developed to close the forearm wound with a flap after harvesting the dovetail flap by creating a dovetailing skin incision with the RFFF. Moreover, the sufficient blood flow and flexibility of RFFF allow for the splicing of the two comparatively independent tails within the dovetail flap for maxillofacial reconstruction.

This study presents a dovetailing skin incision design in the RFFF for primary closure of forearm wounds and reconstruction of maxillofacial defects. The post-surgical outcomes of this procedure were compared with those of the conventional technique in terms of healing time, esthetics, and functional impairment.

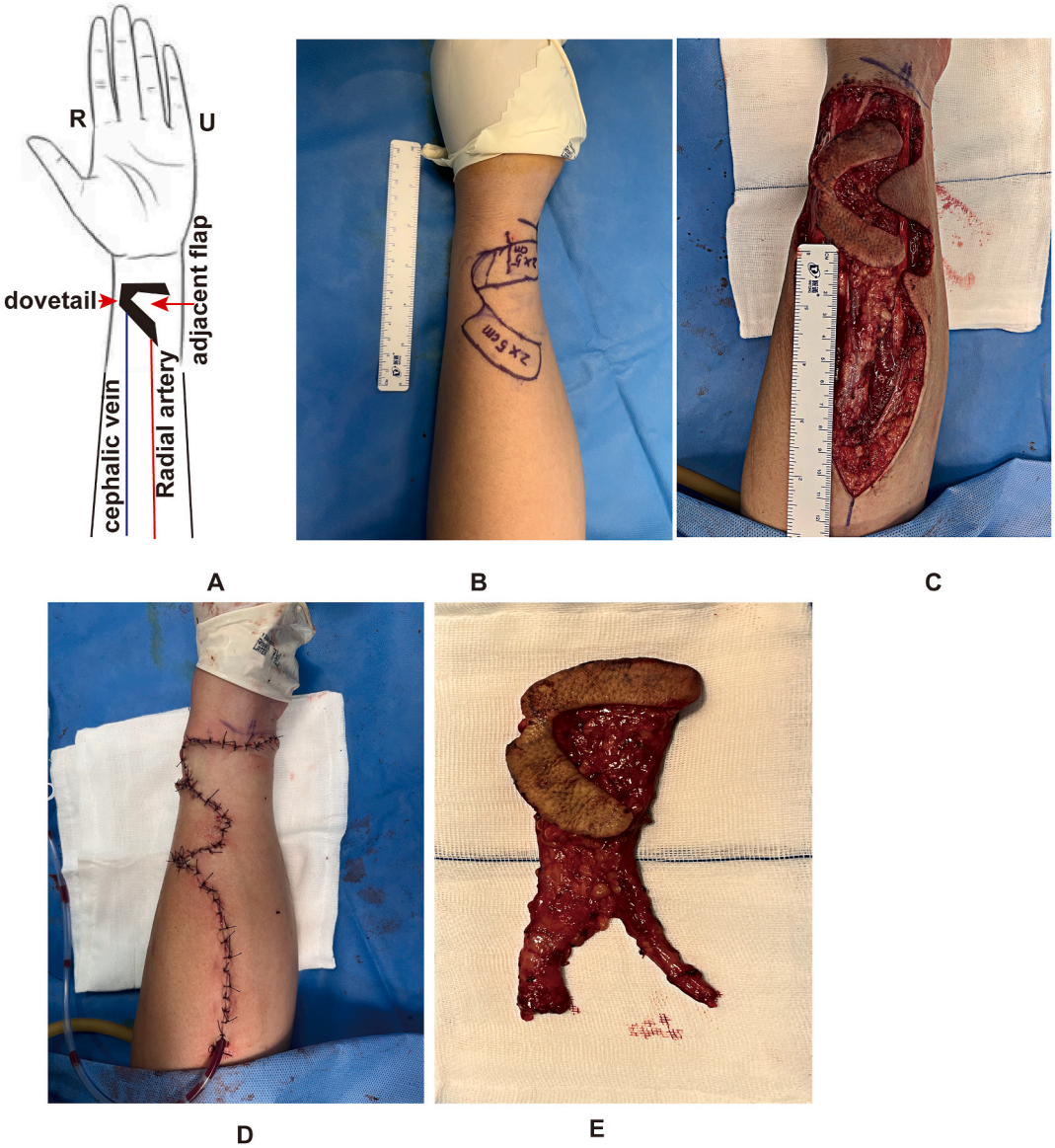

Fig. 1. Schematic illustration of the direct defect closure on the radial forearm
(A) The dovetail incision and the direct closure on the radial forearm, (B) Surgical design of the dovetailing skin incision, (C) Incision and vascular pedicle and flap, (D) Closure of the incision, (E) The completed flap.

2. Patients and methods

2.1. Patients

A retrospective study was conducted from November 2020 to August 2022 in the Department of Oral and Maxillofacial Surgery of the first affiliated hospital in Sun Yat-sen University, Guangzhou, China. The inclusion criteria were: (1) patients who were 18 years old or older; (2) patients who had undergone major resections in the oral and maxillofacial regions; (3) patients with radial forearm free flap reconstruction in dovetailing skin incision design or conventional design; (4) patients with malignant tumors.

The patients were divided into two groups, namely, the dovetail group (n = 16) which was treated using the dovetailing skin incision design in RFFF, and the conventional group (n = 11) which was treated using the conventional design in RFFF. All free flaps were performed by surgeons with more than five years of experience.

2.2. Surgical technique

2.2.1. Technique of dovetail RFFF (dovetail group)

The Allen test was performed to confirm good collateral circulation of the donor hand [11]. The dovetail shape of skin was designed with an angle greater than 60° between the two tails (Fig. 1A and B). The cephalic vein, subcutaneous facial and fat in the gap of the tails were harvested.

After the dovetail flap was harvested, there was a trapezoidal flap left, allowing easy closure of the forearm wound (Fig. 1C and D). The superficial radial nerve was dissected and protected to preserve the distal feeling (Fig. 1C). Meanwhile, the radial and cephalic veins were harvested in the RFFF to set up dual systems venous anastomoses (Fig. 1E). The two independent tails within the dovetail flap were spliced to reconstruct defects in the maxillofacial region, such as floor of the mouth, tongue, cheek, and soft palate. To adapt the technique to specific maxillofacial defects, three types of splicing methods were used: folded oval, trapezoid, and horseshoe (Fig. 2A-D).

2.2.2. Technique of conventional RFFF (conventional group)

The conventional RFFF was harvested as described previously [12], Superficial radial nerve protection and dual venous anastomoses (radial vein and cephalic vein) were ensured. The forearm wound was closed by skin graft from the abdomen or mattress suturing. Finally, the maxillofacial defect was closed using the conventional RFFF without splicing ability.

2.3. Postoperative assessment

The forearm wounds and maxillofacial regions of all patients were examined in the outpatient department and on the phone. The follow-up visits were made at least 6 months after the surgical procedure. The detailed measurements collected are discussed below. Postoperative evaluation was performed by two independent individuals.

2.3.1. Forearm wound assessment

(1) Size of the flap, healing time of the forearm wound, and length of hospitalization after surgery.
(2) Functional analysis was conducted according to Potet's description [13], including wrist flexion (from 1 to 5, 1: bad, 3: common, 5: good), decreased sensitivity (yes/no).
(3) Esthetic assessment was conducted according to Potet's description [13] (on a scale of 1–5; 1: ugly, 3: fair, 5: perfect).

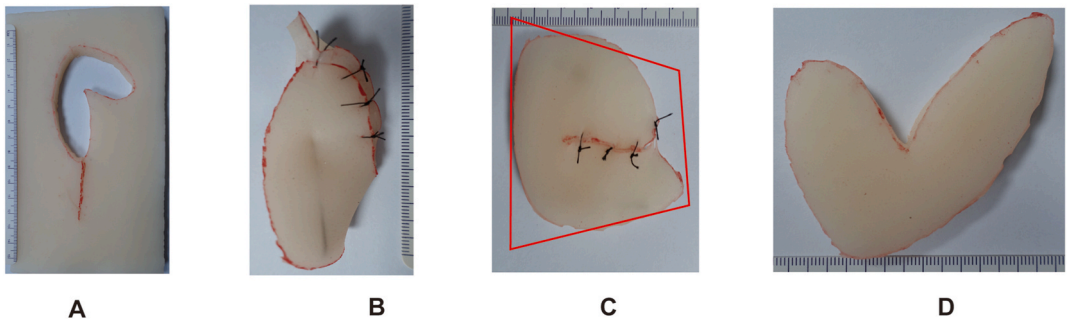

Fig. 2. Splicing methods for maxillofacial reconstruction.
(A) A model of the skin showing the closing process of the forearm wound, (B) Splicing a folded oval, (C) Splicing a trapezoid, (D) Splicing a horseshoe.

2.3.2. Maxillofacial region assessment

(1) Anatomical shape (referring to normal anatomy, on a scale of 1–5; 1: bad, 3: fair, 5: perfect).
(2) Healing complications: infection, fistula, dehiscence, local necrosis, and hemorrhage (on a scale of 1–5; 1: bad, 3: fair, 5: perfect).

2.4. Statistical analysis

Categorical variables were compared between groups using Fisher's exact test. Continuous variables were expressed as means ± standard deviation and compared between groups using t-tests to determine significance. For all statistical analyses, $p < 0.05$ was considered statistically significant. All statistical analyses were performed using SPSS version 23.0 (SPSS, Inc., Chicago, IL, USA).

3. Results

From November 2020 to August 2022, 27 patients divided into two groups were subjected to maxillofacial reconstruction with RFFF. All assessments were completed within six months of the surgery. The flap viability was 100 %.

In the dovetail group, 16 patients with malignant tumors (mean age, 48.8 years) were subjected to the dovetail flap procedure to treat various types of maxillofacial defects across the soft palate, tongue, gum, and cheek. The flaps varied in size from 12 cm^2 to 30 cm^2 (mean, 19.8 cm^2). The dovetail design successfully covered the forearm wounds and maxillofacial defects. All of the flaps survived without local necrosis.

In the conventional group, 11 patients with malignant tumors (mean age, 53.5 years) were treated using the conventional flap. These patients were undergoing salvage surgery for maxillofacial reconstruction across the soft palate, tongue and cheek. The flaps varied in size from 12 cm^2 to 40 cm^2 (mean, 23.3 cm^2). Forearm wounds were closed by skin grafts or mattress suturing.

As shown in Table 1, no differences were found in terms of flap of size ($p = 0.134$) or length of hospital stay ($p = 0.880$). The healing time of forearm wounds in the dovetail group (mean: 16.5 days) was significantly shorter than that in the conventional group (mean: 30.6 days) ($p = 0.000$, Table 2). This means that the primary closure of forearm wounds by the adjacent flap was better than that of the skin graft or mattress suturing. Functional analysis in the dovetail group, including wrist flexion ($p = 0.842$), and feeling ($p = 1.000$) of the operated hand, were similar to those in the conventional group. However, the dovetail group had a better scar esthetic compared with that of the conventional group ($p = 0.000$, Table 2, Fig. 3A and B). Moreover, the anatomical shape of maxillofacial reconstruction in the dovetail group was found to be better than that in the conventional group ($p = 0.000$, Table 2). Meanwhile, no significant differences were observed between the two groups in terms of the healing complications, such as infection, fistula, dehiscence, local necrosis, and hemorrhage ($p = 0.280$, Table 2).

4. Discussion

The RFFF is characterized by its thinness, pliability and constant anatomy with a long pedicle and large vessel diameters. Beyond that, radial bone may be harvested with fasciocutaneous tissue thereby expanding its applications to include reconstruction of composite defects. It is highly suited to repair of defects of the floor of the mouth, cheek, lip, soft palate, and oropharynx [14]. RFFF not only reconstruct defects in head and neck regions, but also it can restore the functions such as swallow [15] and appearance [16].

Closure of the forearm wounds after RFFF harvesting is always secondary to the maxillofacial reconstruction. Autologous whole thickness skin from abdomen or mattress suturing was used to close the forearm defect, but this resulted in several disadvantages [17]. Firstly, taking skin from the abdomen means that there is an additional wound which may negatively impact the appearance and strength of the abdomen [18]. Secondly, local skin graft is associated with a high frequency of donor site complications, delayed healing and unpleasant cosmetic appearance being the most frequent ones [19]. Mattress suturing with excessive tension can lead to necrosis of the local skin [20]. Owing to dovetail design, all forearm wounds were primarily closed without skin graft or mattress suturing in dovetail group. Compared with conventional group, the healing time of the forearm wound following primary closure was significantly shorter ($p = 0.000$), and the scores of the scar esthetic in the donor sites were higher ($p = 0.000$). Additionally, the length

Table 1
Patients' demographics and characteristics.

	Dovetial group N = 16	Conventional group N = 11	*p* value
Age (yr)	48.8 ± 10.3	53.5 ± 13.0	–
Graft size (cm^2)	19.8 ± 3.8	23.3 ± 7.7	0.134
Tumor site			
Tougue	4	7	
Cheeck	7	3	
Soft palat	2	1	
Floor of mouth	2	0	
Gum	1	0	
Length of hospital stay	14.8 ± 4	15.0 ± 4.4	0.880

Table 2
Postoperative characters and complications.

Site	Characters/complications	Dovetail group (n = 16)	Conventional group (n = 11)	*P* value
Donor site	Healing duration (day)	16.5 ± 3.4	30.6 ± 7.4	0.000
	Wrist flexion	4.9 ± 0.5	4.9 ± 0.3	0.842
	Decrease sensitivity	4 (25 %)	2 (18 %)	1.000
	Esthetic assessment	3.8 ± 0.4	2.0 ± 0.6	0.000
Recipient site	Anatomical shape	4.3 ± 0.4	2.9 ± 0.7	0.000
	Healing complications	3.8 ± 0.4	3.9 ± 0.3	0.280

Fig. 3. Esthetic results of the RFFF donor site.
(A) Two months after closure using the dovetailing skin incision design. Esthetic score: four of five, (B) Fifty days after closure using conventional way. Esthetic score: two of five.

of hospital stay in dovetail group was shorter than that of conventional group (14.8 days VS 15.0 days, p = 0.880). The modification flap can reduce closed tension resulting in better healing status. In the past, attempts have been made to reduce the suture tension in the donor sites. The keystone designed RFFF allows primary closure of the forearm wound, but results in the presence of an additional wound in the donor site [13]. Additionally, a snake designed RFFF can also be used for primary closure of the wound in the donor site. Furthermore, to adjust to the maxillofacial defect, a large angle (almost 180°) is required for folding of the fusiform designed RFFF, which can adversely affect the perfusion of the flap [21]. In our study, mean flap size was 19.8 cm^2 which was a relatively small size for defect. Although a large defect in the forearm wound can be covered by another free flap, technical difficulty and operative time increased [22]. Propeller ulnar artery perforator flap can also repair the forearm wound, but the procedure is complicated [23].

The dovetailing skin incision design offers an additional advantage in its molding capabilities by splicing the two tails for maxillofacial reconstruction. The modified design presented in this study was spliced to adapt the shape of the maxillofacial defect, such as trapezoid, horseshoe and folded oval in Fig. 2A-D. The scores of maxillofacial reconstructions using dovetail RFFF were higher

than those of conventional RFFF($p = 0.000$). Difficulties in suturing increase after splicing. In our study, all of the surgeries were undertaken by skilled surgeons. There was no incidence of dehiscence or fistula (3.8 VS 3.9, $p = 0.280$), and the perfusion of the flap was good in the dovetail group. Modification of dovetail design not only allowed adaptation and adjustment for maxillofacial reconstruction, but also did not influence perfusion.

As a modification of RFFF, there were few complications in the donor site. In our study, four patients in dovetail group shown decrease sensitivity, while 2 patients shown similar signs in conventional group (25 % vs 18 %, $p = 1.000$). Additionally, scores of wrist flexion were similar between the two groups ($p = 0.842$). It is well-known that the main complications associated with RFFF harvesting are nerve injury, closure tension, and functional impairment [24]. In our study, although the incidence of decrease sensitivity was high, distribution was relatively limited without obvious effect on daily work. The main cause was the small sample.

An important limitation of the present study is the relatively small sample size, which may limit the ability to find statistical significance in some of the secondary analyses. Secondly, this modification could not be used for large defects. At last, it is also important to note that the surgeons must perform a preoperative evaluation of donor sites and maxillofacial defects when using the dovetail flap.

5. Conclusion

In summary, the results of this study revealed that the dovetail RFFF is a reliable and effective flap. The forearm wound can be closed primarily when the flap size is within a certain range. Additionally, maxillofacial defects can also be reconstructed using the proposed dovetail flaps.

Data availability statement

All data generated or analyzed during this study are included in this article. Any other request about the data, contact e-mail: wanganx@mail.sysu.edu.cn.

Ethics statement

The research was approved by the Ethics Committee of the First Affiliated Hospital of Sun Yat-sen University (No: 2023461, Approved July 8, 2023).

CRediT authorship contribution statement

Shuai Li: Writing – review & editing, Writing – original draft, Software, Methodology. **Shuojin Huang:** Validation, Supervision, Investigation, Formal analysis, Data curation, Conceptualization. **Congyuan Cao:** Validation, Methodology, Formal analysis, Data curation. **Dongxiao tang:** Software, Methodology, Investigation, Formal analysis, Data curation. **Qianting He:** Software, Methodology, Investigation. **Anxun Wang:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

NO.

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