A Double-Skin Paddle Radial Forearm Flap for the Reconstruction of Oral Submucous Fibrosis

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ABSTRACT

Objective: Oral submucous fibrosis can result in progressive restriction of mouth opening. Surgical treatment is indicated for severe cases. An innovative technique, a double-skin paddle radial forearm flap, using only one forearm donor site to reconstruct the bilateral buccal defects, is described. **Patients and Methods:** A total of six patients, having severe oral submucous fibrosis, were treated between July 2002 and August 2004. The surgical procedure consists of (1) release of all the intraoral fibrotic tissue, (2) masticatory muscle myotomy and coronoidotomy, and (3) reconstruction with a double-skin paddle radial forearm flap. **Results:** The preoperative mouth opening was 2 to 5 mm (mean: 3.3 mm). The intraoperative mouth opening ranged from 13 to 20 mm (mean 16.5 mm) after submucous release and ranged from 32 to 42 mm (mean 35.5 mm) after further release via myotomy and coronoidotomy. The proximal flap incorporated one perforator in two patients and two perforators in the remaining 4 patients. The size of the flaps ranged from 8 to 9 cm in length and 2 to 2.5 cm in width. Five flaps survived uneventfully. Arterial thrombosis, developing 24 hours after the operation, was noted in one flap. The flap was successfully salvaged after emergent exploration. Temporomandibular joint subluxation developed in one patient and required surgical reduction. One patient needed flap revision due to bulkiness. The postoperative mouth-opening range was 22 to 37 mm (mean: 30 mm) at an average follow-up period of 19 months. The average increase of the mouth opening was 26.7 mm, compared with the preoperative interincisor distance. **Conclusion:** Double-skin paddle radial forearm flap allowed simultaneous reconstruction of two separate buccal defects using a single donor site and thus obviates the need for a second free flap. (***Tzu Chi Med J*** 2006; **18**:362-369)

Key words: oral submucous fibrosis, double-skin paddle radial forearm flap, masticatory muscle myotomy, coronoidotomy

INTRODUCTION

Oral submucous fibrosis occurs predominantly among Indians living in India as well as other places in the world and to a lesser extent among other Asian people [1]. It is an insidious and chronic disease characterized by the deposition of fibrous tissue in the submucous layer of oral connective tissues that leads to progressive restriction of mouth opening [2]. The disease is also a precancerous condition with incidence of malignant transformation ranging from 3% to 19.1% [2]. Methods of treatment for this disease are medical management and surgical therapy. Medical treatment is indicated at an early stage of the disease. However, most patients with oral submucous fibrosis present with moderate-to-severe

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disease. Surgical treatment remains the method of choice at this late and irreversible stage.

The surgical procedure consists of the release of the fibrous bands via incising the mucosa down to the muscle layer from the angle of the mouth to the posterior pharyngeal area, followed by resurfacing the raw areas with skin grafts, fresh human amnion, buccal fat pad grafts or various local flaps [3-7]. In 2001, Wei and his colleagues were the first to use free flaps (bilateral small radial forearm flaps) for the reconstruction of the buccal mucosa after surgical release of submucous fibrosis; this procedure was a great advance and highly successful [8]. They also emphasized the importance of coronoidotomy and masticatory muscle myotomy in addition to intraoral release of submucous fibrosis and postoperative rehabilitation as an essential part of the surgical treatment to prevent relapse due to postoperative inactivity and scarring [9,10]. The major disadvantages of their technique was that it needed two free flaps involving two separate instances of microsurgery and the use of two forearm donor sites. In this paper, we report an innovative technique, the double-skin paddle radial forearm flap that uses only one forearm donor site for the reconstruction of the bilateral exposed buccal defects.

AND METHODS

A total of six patients were admitted to the Buddhist Tzu Chi General Hospital for treatment of oral submucous fibrosis between July 2002 and August 2004 (Table 1). All these patients had advanced disease with an interincisor distance of no more than 5 mm preoperatively. Patient age, sex, etiology, history of betel quid chewing, preoperative mouth opening, intraoperative maximal mouth opening, size of the flap, perforator number in the proximal flap, complications, donor site morbidity, maximal mouth opening and the development of oral cancer during follow-ups were recorded from a retrospective chart review and recall survey. The patient follow-up time ranged from 9 months to 34 months with an average of 19 months.

Surgical anatomy

The blood supply to the radial forearm flap arises from 9 to 17 septocutaneous perforators of the radial artery, measuring between 0.3 and 0.8 mm in external diameter [11,12]. These septocutaneous perforators emerge in the lateral intermuscular septum between the brachioradialis and the pronator teres proximally and between the brachioradialis and the flexor carpi radialis distally; they run in a transverse orientation relative to the radial artery. Timmons divided the perforators into in two main groups, one within the proximal half and the other within the distal half of the forearm. The proximal group can be further divided into two subgroups. The most proximal perforator arises either close to the origin of the radial artery itself or from the radial recurrent artery. Another major perforator is in the second proximal subgroup. In the distal half of the forearm, the perforators arise approximately 1.5 cm proximal to the radial styloid process and recur proximally at 0.4 to 1.5 cm intervals [11,12]. The distal perforators are more numerous (average number, 9) but smaller than the proximal perforators (average number, 4) [11-14].

According to our cadaveric dissection (Fig. 1) and that of Timmons, there are usually 1 to 3 septocutaneous perforators, arising from the radial artery between 4 to 10 cm distal to its bifurcation, in the second proximal

Table 1. Patient Data

Case	Age/Sex	Preoperative ID	Intraoperative ID after submucous fibrosis release	Intraoperative ID after myotomy and coronoidotomy	Number of perforators in the proximal flap	Complication	ID at follow-up	Follow up (months)
1	60/M	3	17	33	2	Arterial thrombosis, flap survived after exploration	22	34
2	38/M	2	18	38	1		35	29
3	67/F	3	15	33	2		27	19
4	35/M	5	20	32	2		32	12
5	40/M	2	13	35	2		28	10
6	50/M	5	16	42	1	Temporomandibular joint subluxation	37	9
Mean	48	3.3	16.5	35.5			30	19

ID: Interincisal distance (mm)

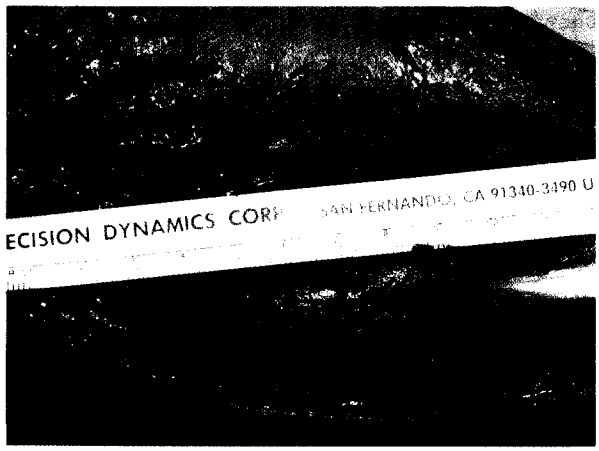

Fig.1. Septocutaneous perforators in the second proximal subgroup.

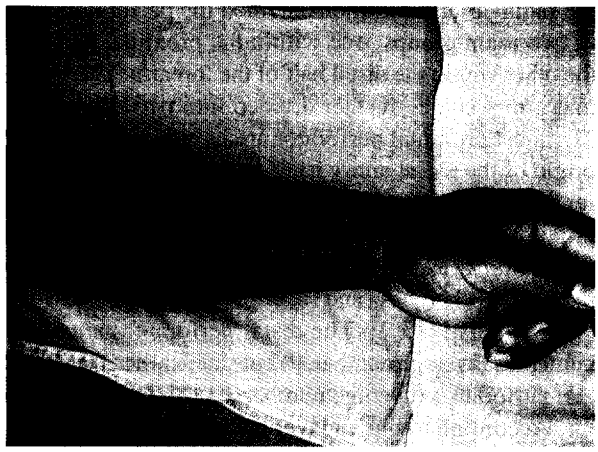

Fig.2. Design of orthograde bipaddled radial forearm flap.

Fig.3. Labiobuccal vestibular incision.

subgroup [11]. Based on these anatomical findings, a bipaddled radial forearm flap can be designed with one skin paddle based on the second proximal perforators and the other skin paddle on the distal perforators. In order to obtain an orthograde radial forearm flap with an adequate pedicle length (at least 4 cm) for microvascular anastomosis with the nearest facial artery and its venae comitantes, the proximal flap is based on the second group of proximal perforators, rather than the most proximal perforators.

Surgical technique

The surgical procedure consists of (1) release of all the intraoral fibrotic tissue from mouth angle to the posterior pharyngeal wall, (2) masticatory muscle myotomy and coronoidotomy and (3) reconstruction with the double-skin paddle radial forearm flap (Fig. 2). Our technique of completely releasing the mucosal fibrosis and myotomy and coronoidotomy is similar to that of Wei and his colleagues and has been well described in previous papers [8,9]; therefore, we will focus mainly on the technical details of the design, elevation and inset of the double-skin paddle radial forearm flap in this paper.

The operation is performed by two teams simultaneously. Under endotracheal general anesthesia, the patient is placed in the supine position with the non-dominant forearm prepared for simultaneous harvest of forearm flap. The buccal mucosa is divided transversely from just behind the mouth angle back to the posterior pharyngeal area at 1 cm below the orifice of the Stenson's duct. Palpation of soft, pliable tissue at the resultant defect verifies the complete release of the fibrous tissue. The coronoid process is exposed through the anterior border of the mandibular ramus. Myotomy of the fibrotic buccinator, temporalis and masseter muscles is performed and followed by coronoidotomies bilaterally. At this point, the dimensions of the resultant mucosa defects are measured, which are typically 2 to 2.5 cm wide and 8 to 9 cm long. Next, a horizontal labiobuccal vestibular incision is made 1 cm above the labial frenulum. The mucosa is incised and raised from the underlying muscles of the lip and cheek, and the dissection is continued down to the mandibular bone. The peri-osteum is incised horizontally and subperiosteal dissection is carried out (Fig. 3).

Design of the orthograde double-skin paddle radial forearm flap on the non-dominant forearm is then carried out (Fig. 2). The long axis of both two flaps is perpendicular or slightly oblique to the radial artery and the larger portion of both flaps is located ulnarward. Using a Doppler flowmeter, the course and the bifurcation of the radial artery is marked. The proximal flap is

outlined first after further identification of the septocutaneous perforators using the Doppler flowmeter. The proximal flap will cover the buccal mucosal defect ipsilateral to the donor forearm. The proximal margin of the proximal flap should be located at least 4 cm distal to the bifurcation. The incision is started on the proximal margin and the ulnar portion of the flap is gradually elevated and should include at least one perforator, which is sufficient for flap perfusion. Thereafter, the distal flap, which will cover the contralateral buccal defect, is outlined. The length of the " bridge pedicle" between these two flaps is 7 to 8 cm. It is easy to include at least one distal perforator, because these are more numerous. The cephalic vein is incorporated within the flap whenever feasible, and dissected proximally beyond the transverse elbow crease to increase its length. After division of the radial artery and its venae comitantes at the bifurcation, the bipaddled flap is elevated, and both skin paddles are carefully inset and anchored to obliterate dead space between the flap and raw surface of the mucosa defect (Fig. 4). Extraction of the third molars avoids inclination of the flaps between the teeth postoperatively. The "bridge pedicle" is placed at the anterior vestibule submucously. Thereafter the recipient facial vessel, ipsilateral to the forearm donor site, is exposed through a 2 cm submandibular incision. The flap pedicle is then passed subcutaneously from the mouth angle down to the recipient vessels. If the cephalic vein is available, it is anastomosed with the external jugular vein. Microvascular anastomoses are then performed in the usual manner. The two donor defects on the forearm are closed primarily after undermining and advancement of the skin flaps. Postoperatively, the patients are fed on a liquid diet through a nasogastric tube for 10 days. Mouth-opening exercises starts on the fifth day postoperatively, and intensive exercise is continued for at least 6 months. All patients are asked to stop chewing betel quid.

Fig. 4. Flap inset.

RESULTS

All of the patients had a habit of chewing betel quid, ranging from 8 to 25 years. The preoperative mouth opening was 2 to 5 mm (mean: 3.3 mm). The intraoperative forced mouth opening ranged from 13 to 20 mm (mean: 16.5 mm) after submucous release and ranged from 32 to 42 mm (mean: 35.5 mm) after further release via myotomy and coronoidotomy. In no patient was there any difficulty in including at least one perforator in the proximal flap. The proximal flap incorporated one perforator in two patients and two perforator in the remaining four patients. The size of the flaps ranged from 8 to 9 cm in length and 2 to 2.5 cm in width. Microvascular anastomosis of the flap pedicle with the facial vasculature was done in five patients and with superior thyroid vasculature in the other patients. Cephalic vein was incorporated within the flap in 3 patients and it was anastomosed with the external jugular vein. Skin grafts were used to cover the two defects on the donor forearms for the initial two patients. The donor defects were closed primarily after undermining and advancement of the skin in the other subsequent four patients. Five flaps survived uneventfully. There was no donor site morbidity. The following complications were noted. Arterial thrombosis, which developed 24 hours after operation, was noted in one flap. After emergent exploration, removal of thrombus and reanastomosis of the artery, the flap survived well. Temporomandibular joint subluxation developed in one patient and required surgical reduction. One patient needed flap revision due to bulkiness. One patient (case 1) failed to exercise regularly, and experienced a significant relapse. The remaining patients did cooperate and exercise daily, and the results were satisfactory. The postoperative mouth-opening range was 22 to 37 mm (mean: 30 mm) after an average follow-up period of 19 months (Fig. 5). The average increase in mouth opening was 26.7 mm, compared with the preoperative interincisor distance. This averaged a 5.5 mm decrease in the mouth opening compared with the intraoperative interincisor distance. Development of oral cancer was not observed over this series.

DISCUSSION

Oral submucous fibrosis was first described in 1952 in five East African women of Indian origin by Schwartz

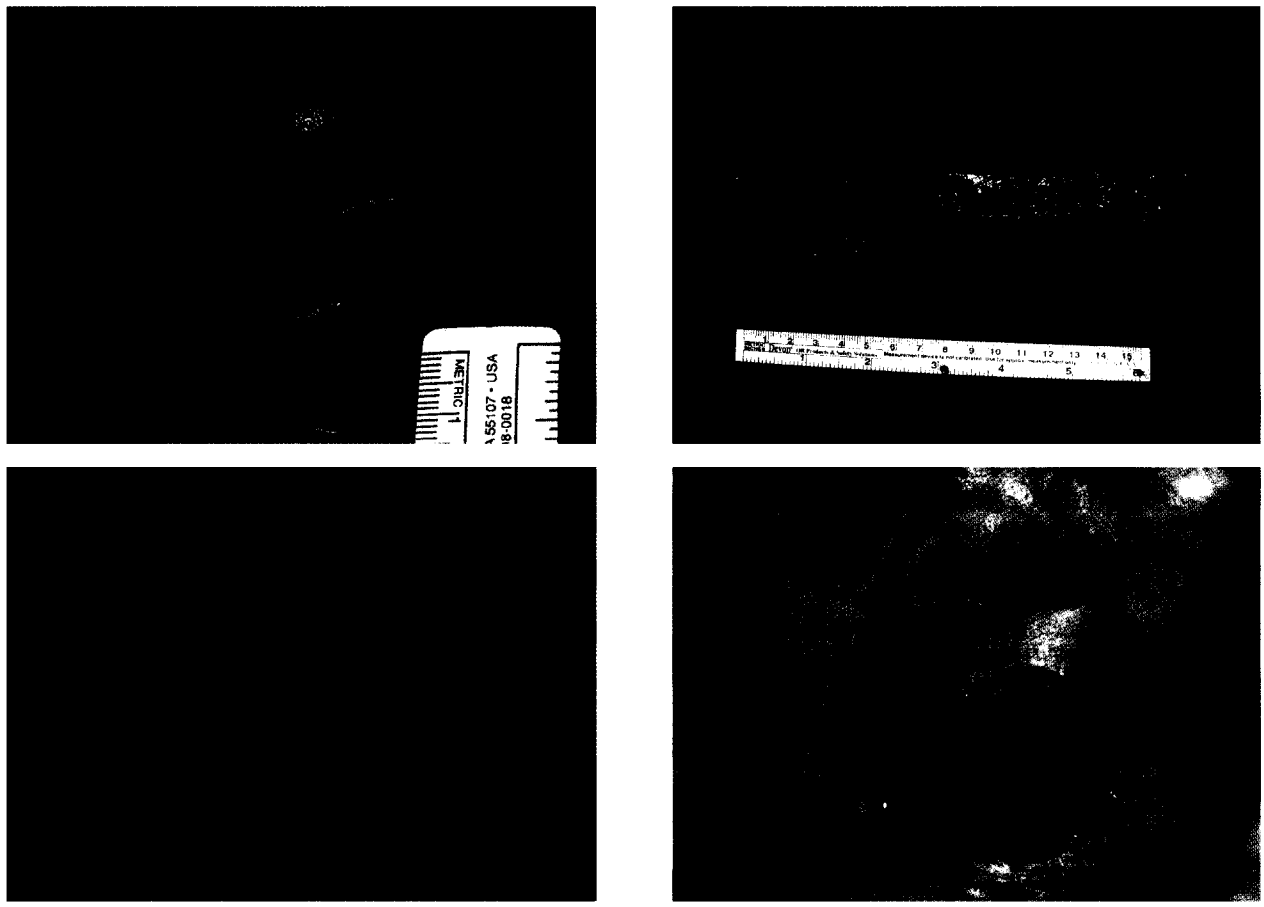

Fig.5. Case 3. (A) Preoperative interincisal distance was 3 mm. (B) Flap elevated. (C) Coronoidotomy. (D) Interincisal distance was 27 mm 19 months after surgery.

who used the term "atrophia idiopathica (tropica) mucosal oris" [15]. One year later, Joshi in India recognized it to be a distinct entity and renamed it "oral submucous fibrosis" [1,16]. The first report of the disease in non-Indians was from Taiwan by Su in 1954. Most large studies have been conducted in India, Pakistan, among Indians in South Africa and in Taiwan [16]. Population-based prevalence figures are available from India and vary from 0.2%-2.3% in males and 1.2%-4.57% in females [17]. The prevalence is highest in southern India. Worldwide, estimates indicate that 2.5 million people are affected and most cases are concentrated on the Indian subcontinent [1]. Patients ranged in age from 2 to 87 years, with a peak incidence between 35 years and 54 years. Most investigators favor a female predominance [17]. Epidemiological studies suggest a multifactoral origin for oral submucous fibrosis, but betel quid chewing has been considered a major etiologic factor. Most studies in India and Southeast Asia have shown an association between areca quid with tobacco and oral mucosal lesions. Although the areca/betel quid in Taiwan does not contain any tobacco, a significant association has still identified between areca/betel quid chewing and oral mucosal lesions including oral submucous fibrosis [18,19]. There are more than 2 million people in Taiwan who are in the habit of chewing betel quid, but the exact prevalence of oral submucous fibrosis has not been studied in detail [18].

Patients with oral submucous fibrosis have an increased risk of developing oral cancer. Tobacco is the component of the quid believed to be most associated with cancer development. The carcinogenic properties of the areca nut were discovered after it was noticed that cancer still occurred in women who chewed the nut without tobacco [20]. The incidence of malignant transformation in patients with oral submucous fibrosis ranges from 3% to 19.1% [1,2,17]. No patient developed squamous cell carcinoma of the oral cavity during this series. However, our sample size is too small and the average follow-up time is too short to allow any significant com-

parative analysis.

Once present, oral submucous fibrosis does not regress, either spontaneously or on cessation of betel quid chewing. Medical treatment is indicated at an early stage of the disease, is largely symptomatic and aimed at improving mouth movements. Treatment may include steroids, placental extracts, hyaluronidase and interferon [17]. However, no treatment is effective, and the condition is irreversible. Surgical treatment is indicated in patients with severe trismus and/or biopsy results that reveal dysplastic or neoplastic changes. A variety of surgical modalities have been used. Simple excision of the fibrous bands can result in increased scarring and exacerbation of the condition. Results with split-thickness skin grafting, fresh human amnion, or buccal fat pad grafts to cover the raw surfaces after resectioning of the fibrous bands have been disappointing [4,8]. The incidence of shrinkage, contracture and infection of the grafts is high because of poor oral conditions and recurrence of symptoms usually develops [4,8]. Resurfacing the defects with various local flaps has several disadvantages. Tongue flaps are bulky and require additional division surgery. Bilateral tongue flaps cause disarticulation and dysphagia and increase the risk of aspiration. The tongue is involved in 38% of cases and this may preclude its use. Both nasolabial flaps and palatal island flaps limit the flap size and there is difficulty in reaching the posterior raw surface. The nasolabial flap also cause facial scars and needs secondary division [4, 8]. The technique of bilateral small free radial forearm flaps has the merits of transferring a well vascularized skin flap, the prevention of scar contracture and a decrease in the recurrence of trismus [8]. However, it also has a number of major disadvantages: two flaps and two instances of microsurgery are required, the procedure is time-consuming, technically demanding and it involves two forearm donor sites with the sacrifice of bilateral radial arteries. Another concern is that 3%-19% of these patients will develop oral cancer and the use of this procedure eliminates the forearm as a free flap donor site and precludes its future use for oral reconstruction after oral cancer removal.

According to Timmons study, the septocutaneous branches of radial artery tend to form three groups, two in the proximal half and one in the distal half of the forearm, with three corresponding zones of perfusion [11]. Bisecting or splitting the radial forearm flap or other fasciocutaneous flaps such as the peroneal artery, anterolateral thigh or lateral arm flap into multiple segments, basing on the individual perforators, is not novel to most plastic surgeons [21-23]. However, our technique is unique in that we place a "bridge pedicle" between the two skin paddles under the mucosa of anterior vestibule and the longitudinal orientation of the two skin paddles to radial artery makes the "bridge pedicle" long enough for our task. Although the length-to-width ratio range from 3:1 to 4 :1, the viability of both skin paddles is good because they incorporate at least one axially running perforator. In order to obtain an adequate pedicle length of at least 4 cm for microsurgical anastomosis with the facial vasculature, the proximal skin paddle was based on the second proximal perforators [11]. Also obviating the use of a second forearm donor site may be the bipaddled, retrograde radial forearm flap [16] (Fig. 6A) or a radial forearm flap that is divided into two separate, independent free flaps with either orthograde or retrograde flow [18] (Fig. 6B) and inset into both buccal mucosal defects. The latter needs a second microvascular anastomosis.

The advantages of radial forearm flap include constant vascular anatomy, a thin and pliable flap, ease of flap elevation and a long vascular pedicle with adequate size for anastomosis. However, possible functional and aesthetic morbidities at the donor site of the radial forearm flap are well recognized. A skin graft at the donor site can lead to delayed wound healing and tendon exposure, and the resultant scarring is also remarkably unsightly. In our initial two cases, two split-thickness skin grafts were used to cover the two donor defects of the forearm. The resultant unsightly scar was a major drawback of our technique (Fig. 7A), compared to the bilateral small radial forearm flaps technique, in which primary closure of the donor defects over the bilateral forearms were done. However, in the subsequent 4 cases,

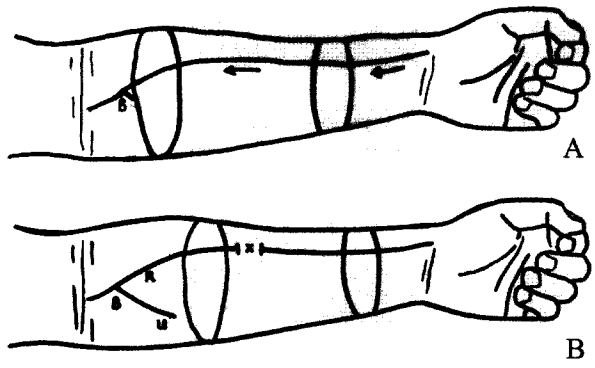

Fig. 6. (A) Bipaddled, retrograde radial forearm flap with one skin paddle based on the most proximal perforator and the other on the distal perforator. The distal radial artery with its venae comitantes is used for anastomosis with the recipient facial vessels. (B) Two independent radial forearm flaps can be created. Each flap is used to cover each buccal defect.

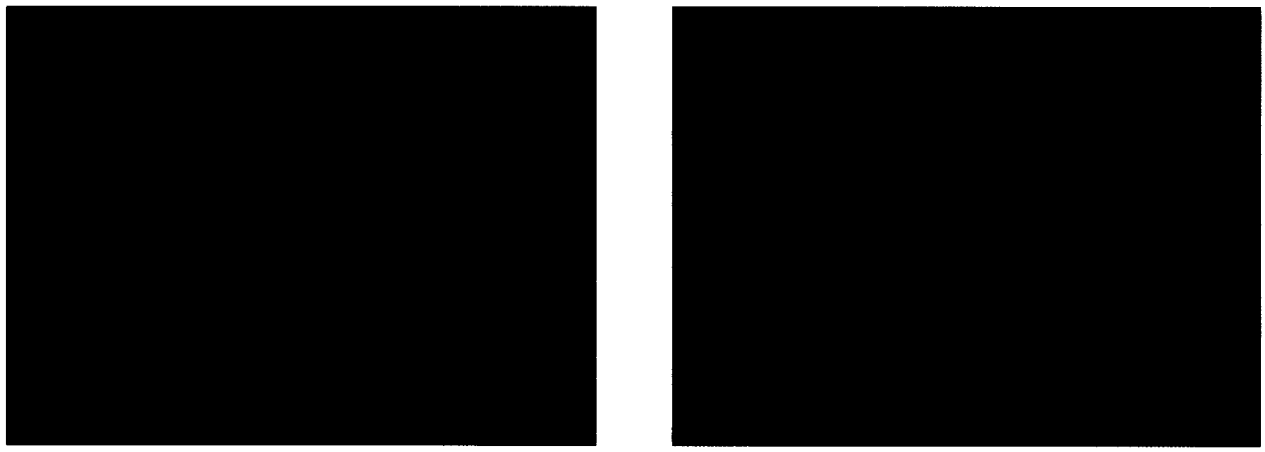

Fig. 7. (A) Scar after skin grafting. (B) Scar after primary closure.

the two donor defects were closed primarily after adequate undermining and advancement of the skin flaps and this resulted in a more acceptable linear scar (Fig. 7B). Furthermore, it eliminated problems of delayed wound healing and tendon exposure associated with skin grafting.

Although, in the opinion of some surgeons, routine temporalis myotomy and coronoidotomy are unnecessary [6], our results agree with previous reports showing that coronoidotomy and masticatory muscle myotomy is important when treating advanced oral submucous fibrosis [4,9]. During the follow-up period, a 5.5 mm decrease in mouth opening size was noted in our series and this can be attributed to poor compliance by some patients and to variation in the severity of the initial disease in this series.

CONCLUSIONS

The double-skin paddle radial forearm flap allowed simultaneous reconstruction of two separate buccal defects using a single donor site and this eliminates the need for a second free flap.

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雙皮瓣前臂橈動脈自由皮瓣用於口腔黏膜下纖維化的重建

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摘要

目的：口腔黏膜下纖維化可導致逐漸的開口限制。外科治療適用於嚴重的病例。本文描述一種創新的手術：雙皮瓣前臂橈動脈自由瓣(僅用一側的前臂供皮瓣區)來重建兩側的頰黏膜缺損，並報告治療結果。**病人與方法**：從2002年7月到2004年8月，共6位嚴重口腔黏膜下纖維化的病人接受治療。手術方法包括(1)鬆解所有口內纖維化的組織，(2)咀嚼肌肉切開術及喙狀突切斷術，(3)用雙皮瓣前臂橈動脈自由瓣來重建。**結果**：術前開口為2至5公釐(平均3.3)，經黏膜下鬆解後，術中開口為13至20公釐(平均16.5)，經進一步肌肉切開術及喙狀突切斷術後，術中開口為32至42公釐(平均35.5)。2位病人近端皮瓣包含1個穿透枝，4位包含2個穿透枝。皮瓣大小：長8至9公分，寬2至2.5公分。5個皮瓣順利存活，1個皮瓣24小時發生動脈栓塞，經緊急探查，皮瓣成功救回。1位病人出現顳頜關節半脫位，需要手術復位。1位病人因皮瓣太大，需要修正。平均追蹤19個月，術後開口為22至37公釐(平均30)。和術前的上下門齒間距相比，平均增加的開口為26.7公釐。**結論**：雙皮瓣前臂橈動脈自由瓣(只利用一處供皮瓣區)允許同時重建兩側分開的頰黏膜而免除了第二個自由皮瓣。(**慈濟醫學** 2006; **18**:362-369)

關鍵語：口腔黏膜下纖維化，雙皮瓣前臂橈動脈自由瓣，咀嚼肌肉切開術，喙狀突切斷術

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運用有限元素分析法進行生物力學模擬軟骨耳膜修補術最佳化設計

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摘要

目的：本篇實驗的目的在研究軟骨的聲音傳導特性，以達到最理想的軟骨耳膜修補手術。**材料與方法**：我們發展一套合併軟骨跟耳膜的有限元素模型來模擬軟骨耳膜修補的特性，從大體上取得的耳珠軟骨跟平均的耳膜模型來實驗，耳珠軟骨的參數包括曲度跟交叉測量，軟骨被重建在立體中耳模型的耳膜破洞上，利用有限元素模型來計算最佳耳膜修補的軟骨厚度。**結果**：減少軟骨的厚度可以增加聲音傳導的品質，從聲音傳導來看，0.1到0.2公厘厚度的軟骨最適合耳膜震動。**結論**：從聲音的觀點來看軟骨對於耳膜重建是相當有用的，聲音傳導損失可以利用較薄的軟骨來減少，0.2公厘的軟骨可以用在低頻、0.1公厘的軟骨可以用在高頻，一方面能達到力學上的穩定度並且減少聲音傳導的損失。(**慈濟醫學** 2006; **18**:370-377)

關鍵語：軟骨耳膜修補術，中耳生物力學，多重身體動態分析，數學上的模型

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