SCIENTIFIC ARCHIVES OF DENTAL SCIENCES (ISSN: 2642-1623)

Volume 7 Issue 9

Research Article

Split-Thickness Skin Grafts in the Surgical Management of Oral Submucous Fibrosis

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Received: February 17, 2025; **Published:** March 24, 2025

Abstract

Introduction and Objective: Oral submucous fibrosis (OSF) is a progressive, chronic condition that manifests primarily with a burning sensation upon consuming spicy foods in its early stages and trismus in its advanced phase. Managing these symptoms is challenging, often requiring conservative measures in the initial stages and surgical interventions later. This study aimed to evaluate the efficacy of surgical treatment for trismus in OSF through surgical fibrolysis and split skin graft application and assess long-term outcomes.

Methods and Materials: We conducted a retrospective hospital-based study involving 25 patients selected from a cohort 170 diagnosed with OSF at the Oral and Maxillofacial Surgical Hospital, Rajkot, India. Surgery was indicated for patients with inter-incisal distance (IID) measurements ranging from 0.00 cm (complete trismus) to 2.5 cm, with patients exhibiting IID greater than 2.5 cm not included in surgical treatment. Comprehensive patient records were maintained, and follow-ups were conducted for at least three years postoperatively. IID measurements were taken pre-operatively, intra-operatively, immediately post-operatively, and subsequently at 6 months, 1 year, 2 years, and 3 years post-surgery.

Results: The average IID for the 25 patients preoperatively was 1.49 cm, which improved to 2.86 cm intra-operatively and 3.40 cm immediately post-operatively. Follow-up IID measurements at respective intervals were as follows: 3.51 cm at 6 months, 3.45 cm at 1 year, 3.43 cm at 2 years, and 3.44 cm at 3 years. This demonstrates an overall improvement from preoperative IID of 1.49 cm to 3.44 cm after three years. Statistical analysis revealed significant results with a p-value < 0.05.

Conclusion: The surgical excision of fibrous bands followed by split skin grafting of the buccal mucosa has shown promising long-term outcomes without complications, establishing it as an effective treatment modality for trismus in OSF. A comprehensive surgical protocol for applying skin grafts in OSF is proposed.

Keywords: *Oral Submucous Fibrosis; Trismus; Surgery in OSF; Skin Grafts*

Introduction

Oral submucous fibrosis (OSMF) is a chronic, progressive, irreversible scarring disease predominantly affecting individuals of Southeast Asian descent. Schwartz (1952) first described this condition while examining five Indian women in Kenya, labeling it "atrophic idiopathic (tropica) mucosae Oris" [1]. Subsequently, Joshi (1953) redefined it as oral submucous fibrosis, emphasizing its histopathological characteristics [2]. According to the World Health Organization, OSF qualifies as an oral precancerous condition characterized by a generalized pathological state of the oral mucosa with a significantly increased risk of malignancy [3].

The disease has gained recognition as a significant health concern within the Indian subcontinent, with higher prevalence in India, Pakistan, Sri Lanka, Nepal, and regions with Indian diasporas, including Europe and North America. Clinically, patients typically present with two main complaints: a burning sensation in the mouth—especially while consuming spicy food—and progressive trismus. Clinical assessments commonly reveal severe oral ulcerations, white blanched mucosa, and submucosal fibrous bands contributing to restricted mouth opening [4].

A biopsy is critical to exclude potential malignant transformations despite primarily being diagnosed clinically. The underlying fibrosis may extend into the musculature, forming dense fibrous bands that typify this disorder. The condition inflicts significant morbidity due to eating difficulties and has prompted various surgical interventions, ranging from the release of fibrous bands to more extensive reconstructive procedures, including the release or excision of intra-oral fibrous bands, coronoidectomies, muscle of mastication myotomies, and soft tissue reconstruction with split-thickness skin graft or allograft [5].

The various local or distant tissue flaps used for covering raw areas after surgical excision of the fibrous bands are either intra oral tissue flaps or extra oral tissue flaps and include naso-labial flaps, palatal flaps, buccal fat pad tissue, lateral tongue flaps, radial forearm free flaps, antero-lateral-thigh flaps, vascularized temporal myofascial flaps, and submental flaps. Other techniques include split skin grafts, absorbable collagen membranes, collagen/silicone bilayer membranes, and lasers. Each of these techniques has its advantages and disadvantages and works best in the hands of those who advocate it. The classification of these various techniques is mentioned in table 1.

EXTRA ORAL FLAPS	INTRAORAL FLAPS	MICRO-VASCULAR FREE FLAPS	SKIN AND ORAL MUCOSA SUBSTITUTES
1. Naso-Labial Flap	1. Tongue Flaps	1. Radial Forearm Free Flaps	1.Collagen Membrane
2. Superficial Temporal Fascia Pedicled Flaps	2. Palatal Island Flaps	2.Anterolateral Thigh Flaps	2. Artificial Dermis.
3. Platysma Myocutaneous Muscle Flaps	3. Buccal Fat Pad Flaps		3. Amniotic Membrane
4. Submental Flaps			
			ADDITIONAL TECHNIQUES
		Split Thickness Skin Grafts	Lasers

Table 1: *Classification of various techniques used in the surgical management of oral submucous fibrosis*

For cases in which initial surgical intervention is unsuccessful (recurrent trismus; usually secondary to lack of compliance with physical therapy or surgical failure), more aggressive surgical treatment is indicated. Again, excision of any fibrous bands intraorally and repeated masticatory muscle myotomy is required. This often results in a larger buccal soft tissue defect, requiring significant reconstruction. This can include a pedicled temporalis flap, a pedicled superficial temporalis fascial flap, or a radial forearm free flap combined with split-thickness skin graft coverage [6].

Postoperative physical therapy is essential, as non-compliance can lead to recurrent trismus. Patients must be informed that OSF remains unresolved even after surgery, underscoring the need for lifelong management strategies, including cessation of areca nut and tobacco use and consistent oral cancer surveillance.

Materials and Methods

This retrospective study was conducted at the Oral and Maxillofacial Surgery Hospital in Rajkot, Gujarat, India, involving 170 patients diagnosed with OSF based on specific clinical criteria, notably burning sensations when consuming spicy food and progressive trismus. The diagnosis was confirmed via biopsy. Relevant demographic and clinical data were collected, including the history of areca nut and tobacco use and oral hygiene conditions. Interincisal distance (IID) was measured using calipers, and additional radiological examinations were performed as required.

Patients exhibiting marked trismus (IID < 2.5 cm) were offered surgical treatment through fibrolysis and skin grafting. Informed consent was obtained from all participants. The cohort consisted exclusively of males aged 21 to 40, with an average age of 30.5 years.

Inclusion criteria:

1. Confirmed diagnosis of OSF via clinical and histopathological examination.
2. IID < 2.5 cm.
3. Informed consent from patients with a comprehensive understanding of the procedure.
4. Commitment to quit tobacco for the duration of postoperative care.
5. Patients in good general health with regular blood and urine tests.

Exclusion criteria:

1. IID > 2.5 cm.
2. Patients primarily complain of burning sensations without significant trismus.
3. Patients cannot comprehend the surgical procedure or refuse to consent.
4. High expectations for surgical outcomes.
5. Non-compliant patients regarding tobacco use or oral physiotherapy.
6. Presence of significant comorbidities or signs indicative of oral squamous cell carcinoma (OSCC).

Preoperative assessment

Preoperative evaluations included a comprehensive medical history and physical examination to assess adverse health conditions.

Surgical procedure

The procedure involved removing fibrous bands and resurfacing the raw area created in the buccal mucosa bilaterally by a thick split skin graft. All surgeries were performed under general anesthesia.

A stepwise surgical procedure is described to provide a better understanding of the procedure (Figure 1 and 2):

1. **Step No. 1**: [Induction of Anesthesia]: General Anesthesia was induced by Naso-endotracheal intubation or a Fibre Optic Bronchoscope. The emergency tracheostomy set was always ready.
2. **Step No. 2:** [Incision]: Horizontal Incision was taken into both buccal mucosae beginning from a point just behind the oral commissure, going posteriorly to a point just in front of the palato-lingual fold, avoiding injury to the opening of the parotid gland. This incision runs between the occlusal surfaces of the upper and lower teeth, and its depth is limited to the oral mucosa.
3. **Step No. 3:** [Exposing Fibrous Bands]: After primary incision in both the buccal mucosa, its depth being restricted only to the mucosa, with the help of mouth prop, the mouth is forcefully open, taking care of the teeth. This opens incisions in the buccal mucosa triangularly, with the tip positioned posteriorly and exposing underlying fibrous bands and musculature. IID is measured and recorded (Intraoperative IID).

4. **Step No. 4**: [Fibrolysis]: After fibrous bands are exposed, they are removed (Fibrolysis) by palpating fibrous bands with fingers till typical fibrous bands free tissue is felt under palpating fingers. At this stage, surgical myotomies of the fibrosed muscles may have to be performed to get the desired results. Excessive tissue at the posterior end of the incision is excised to give the raw area a rectangular shape. Bleeding points are checked and bleeding controlled.
5. **Step No. 5**: [Obtaining Skin Graft:] A Thick Split skin graft is obtained using a suitable skin-grafting knife from hair-less areas of the skin. The most appropriate location is the medial surface of the forearm. The donor area is covered with dressings. Skin graft is divided into two parts for each buccal mucosa and cut into proper shape. Any fat globules and other tissues attached to the raw area of the graft are excised, and the graft is made ready to place on the recipient site.
6. **Step No. 6:** [Skin Grafting]: Skin grafts are placed on the raw areas created in the buccal mucosa bilaterally, their edges matched, and skin grafts are sutured into position using absorbable suture material. One end of the suture is kept long to put tie-over bolster dressing on the skin graft. To create pressure on skin grafts and stabilize them, softened dental compound is pressed onto the skin grafts and between teeth on both sides. IID is measured (Immediate Postoperative IID).
7. **Step No. 7** [End of Surgery]: After securing grafts in position, Ryle's tube is passed through the nose, and the patient is extubated (Figure 3).

Figures 1: Split Thickness Skin Grafts: Graphic Presentation of the Surgical Technique

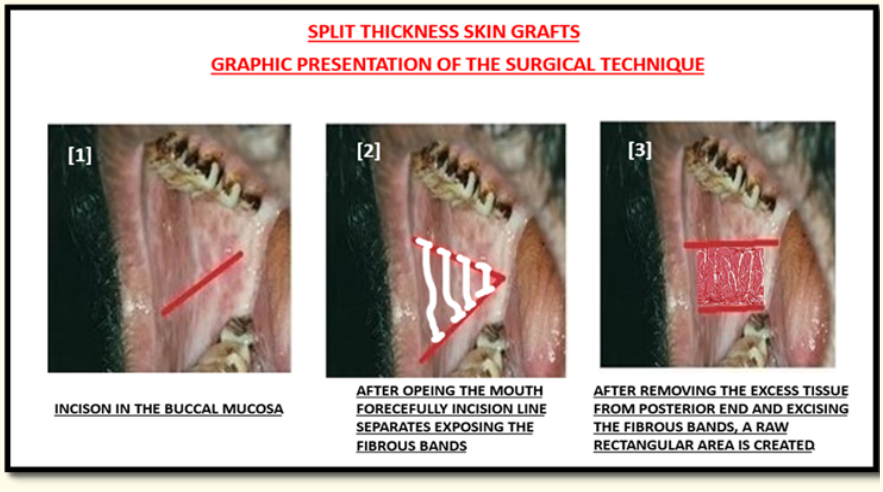


Figure No. 2: Split Thickness Skin Graft: Graphic Presentation of the Surgical Technique

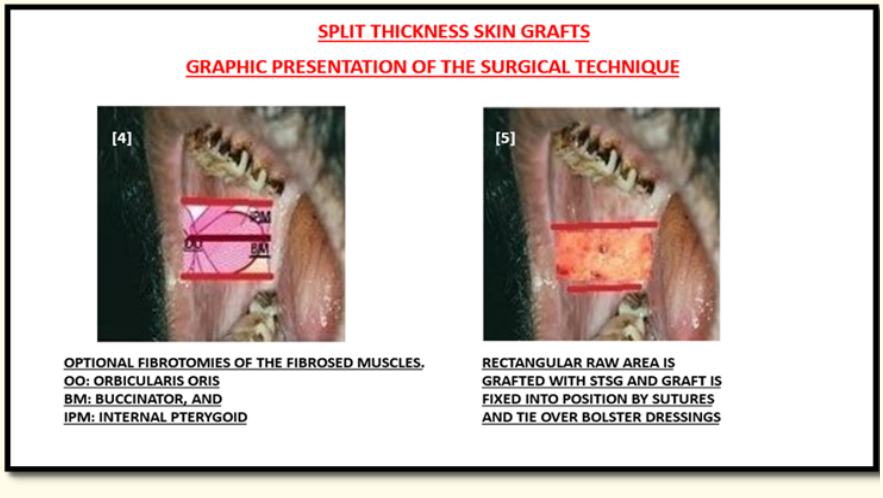


Figure No. 3

SECURING SKIN GRAFT BY DENTAL COMPOUND AND RT FEEDING.

Postoperative course

Patients remained hospitalized for one week, receiving nutritional support via Ryle's tube. At the end of that period, tubes and dressings were removed, and oral physiotherapy was initiated. Follow-up appointments were scheduled for six months, one year, two years, and three years postoperatively, with IID measurements taken at each visit.

Measurement of IID

Inter-incisal distances were measured at various time points to assess surgical outcomes:

1. Pre-operative.
2. Intraoperative.
3. Immediate postoperative.
4. Follow-up assessments at six months, one year, two years, and three years.

Results

The surgical intervention was performed on 25 male patients presenting with significant trismus. The average IID measurements highlighted a substantial improvement in post-surgery. The average preoperative IID was 1.49 cm, while intraoperative IID was recorded at 2.86 cm, and immediately postoperative IID reached 3.4 cm. The average IID was 3.51 cm in six months, stabilizing at 3.45, 3.43, and 3.44 cm in one year, two years, and three years, respectively. The findings demonstrated a statistically significant increase in IID (p-value < 0.05), indicating favorable surgical outcomes and improved quality of life for patients suffering from trismus secondary to OSMF (Table 2).

Results of STSG in the Surgical Management of Oral Submucous Fibrosis (CMS)

Sr. No.	PREOP IID	INTRAOP IID	POSTOPIID	6MONTHS IID	ONE YEAR IID	TWO YEARS IID	THREE YEARS IID
1	2.3	3.2	3.8	3.8	3.5	3.5	3.4
2	1.6	2.9	3.2	3.4	3.3	3.3	3.3
3	2.1	2.8	3.4	3.4	3.5	3.5	3.5
4	1.2	2.9	3	3.2	3.3	3.4	3.9
5	2.2	3.1	3.3	3.5	3.5	3.4	3.4
6	0.8	2.5	3.1	3.3	3.3	3.2	3.2
7	1.1	2.3	2.9	3.6	3.5	3.4	3.4
8	1.5	2.6	3.2	3.4	3.5	3.4	3.4
9	0.6	2.4	3	3.2	3.3	3.2	3.2
10	2.1	3.4	3.6	3.7	3.7	3.6	3.6
11	2.3	3.7	3.6	3.6	3.5	3.5	3.5
12	2.4	3.7	3.7	3.8	3.7	3.7	3.6
13	0.4	2.3	3	2.9	3.1	3.1	3.1
14	0	1.8	2.4	3.1	3	3.4	3.4
15	1.9	2.8	3.8	3.6	3.5	3.5	3.5
16	0.9	2.4	3.6	3.5	3.4	3.4	3.4
17	1.2	2.6	3.8	3.7	3.5	3.5	3.5
18	2	2.8	3.6	3.9	3.8	3.8	3.8
19	1.6	3.1	3.7	3.6	3.6	3.5	3.5
20	2.3	3.5	3.8	3.7	3.6	3.6	3.6
21	0.2	2.4	3.1	3.5	3.4	3.3	3.2
22	1.9	3.3	3.6	3.5	3.4	3.2	3.2
23	2.2	3.1	3.8	3.6	3.5	3.5	3.5
24	0.7	2.6	3.4	3.6	3.4	3.4	3.4
25	1.8	3.4	3.8	3.7	3.6	3.6	3.6
AVERAGES:	1.49 CMS	2.86 CMS	3.40 CMS	3.51CMS	3.45 CMS	3.43 CMS	3.44 CMS.

Table 2: *Results of STSG in the surgical management of oral submucous fibrosis (CMS).*

In conclusion, surgical fibrolysis coupled with skin grafting shows promise as an effective intervention for managing trismus in patients with OSF, provided that comprehensive postoperative care and lifestyle modifications are adhered to.

Discussion

Though described for the first time by Schwartz [1] in the year 1952 as "Atrophica Idiopathic (tropical) mucosa Oris, "The credit for more appropriate terminology describing this condition goes to Joshi [2] as an "Oral Sub mucous Fibrosis". Other names for OSF are "diffuse oral submucosal fibrosis", "idiopathic scleroderma of mouth", "idiopathic palatal fibrosis", sclerosing stomatitis", and "juxta-epithelial fibrosis", Pindborg [4] defined OSF in the year 1966 as follows: "As an insidious, chronic, irreversible disease affecting any part of the oral cavity and sometimes pharynx, although occasionally preceded by and/or associated with juxta-epithelial inflammatory reaction followed by fibroelastic changes of lamina propria with epithelial atrophy leading to stiffness of oral mucosa and causing trismus and inability to eat".

However, adding the word "irreversible "or "incurable "will describe OSF more appropriately, considering present knowledge of OSF [7].

Nanavati., *et al.* [7] propose the following definition of the OSF, which includes histopathological and clinicopathological features and the treatment of OSF: "An insidious, chronic, irreversible disease, a potentially malignant fibrotic disorder, behaving surreptitiously, progressing stealthily so as not to be detected in early stages, affecting the entire oral cavity and seldom the pharynx and esophagus, preceded by vesicle formations, followed by a juxta-epithelial inflammatory reaction and a fibroelastic change of the lamina propria with epithelial atrophy, which leads to stiffness of the oral mucosa, progressive decrement in mouth opening and inability to eat, and is difficult to treat, both conservatively and surgically in early or late stages".

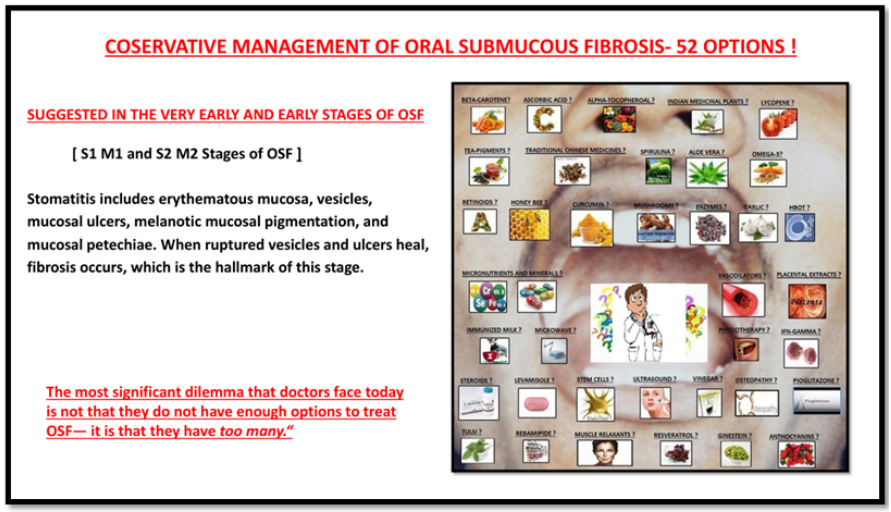
The definition proposed by Nanavati., *et al.* [7] designates OSF being a critical oral disorder with four distinct clinical stages. It needs timely treatment to prevent the spread of oral cancer worldwide.

A plethora of literature is published on the treatment of OSF, with each clinician claiming better success than the other. However, most clinicians attempt to relieve symptoms associated with OSF, primarily a burning sensation in the mouth while eating spicy food in the early stage of the disease, when inflammation, ulceration, and vesiculations dominate the clinical picture. Various clinicians have administered a dizzying array of treatment modalities at this stage, mainly conservative, non-invasive treatments. Success has been claimed by using intra-lesional steroids. Lycopene, micronutrients, milk from immunized cows, pentoxifylline, interferon gamma, placental extracts, turmeric (Curcumin-diferuloylmethane), chymotrypsin, hyaluronidase, dexamethasone, levamisole, vitamin A, and stem cell therapy [8-25]. The conservative, non-invasive treatment of OSF consists mainly of intra-oral submucosal injections of various drugs suggested, or it may include ingestion of oral medications. Conservative treatment of OSF is primarily effective during the first two stages of the disease when the patient's chief complaint is a burning sensation in the mouth (Figure 4).

When the disease advances to the late stage of OSF, when trismus predominates the clinical picture, surgical treatment is attempted. Essentially, surgical treatment consists of the excision of fibrous bands and covering the raw area created by various local or distant flaps, and the hope for the trismus to be relieved. The different local or distant tissues used for covering raw areas after surgical excision of the fibrous bands are Naso-labial pedicled grafts, Forehead flaps, Palatal flaps, buccal fat pad tissue, Lateral tongue flaps, Absorbable collagen membrane, Radial Forearm Free Flaps, ALT thigh flaps, Vascularized Temporal myofascial flaps, and Collagen/silicone bilayer membrane and split-thickness skin grafts [26-47] (Table 1). A few clinicians have also advocated Lasers [34,47,48]. Each technique has its advantages and disadvantages and works best in the hands of those who advocate it.

None of the interventions reported, either conservative non-invasive medical or invasive surgical interventions, have reported any improvement in oral health-related quality of life among patients treated for OSF. Both main clinical symptoms, burning sensation in the mouth while eating spicy hot food and progressive inability to open the mouth fully (Trismus), can affect oral functions, Oro-facial

Figure No.4: Conservative Management of Oral Submucous Fibrosis



appearance (sunken cheeks), and social interactions (difficulty in speech and deglutition) [49].

Few reviewers, like Ramesh Ram [50], believe that the appropriate treatment, whether conservative or invasive, can be decided only after studying individual mechanisms operating at various OSF stages—initial, intermediate, and advanced.

In 2015, Kamath [51] reviewed articles on the surgical treatment of OSF. Fifty-six articles have been published on this subject, and 995 surgically treated cases are included in the analysis.

According to Kamath [51], very few controlled trials have been conducted, and most randomized surgical trials have been conducted on a few patients with a short follow-up. Surgical procedures depend upon clinicians' preferences, and no definite protocols for treating OSF exist. Adequate documentation and follow-up need to be established to statistically analyze various treatment modalities' results and proclaimed successes.

Meticulous planning by the surgeons is required as the oral cavity presents a unique environment:

1. The oral cavity is a mobile structure.
2. The oral cavity involves the human body's most important physiological functions, nutrition, and speech.
3. The oral cavity has a wet environment since it is regularly bathed in saliva.
4. Securing grafts intraorally is a technically demanding task.
5. The graft bed has a compromised blood supply.
6. Demands extreme cooperation from the patient.
7. Post-operative care is very significant.
8. A small working field with additional restrictions because of trismus.
9. Intraoral surgery is performed near critical anatomical structures.

The wide variety of reconstructive options available to the surgeon has raised many questions, and the increasingly important factors that determine the choice of reconstructive alternatives are described by Rigby, Matthew H, and S Mark Taylor [73] as follows:

1. The potential for restoring oral functions.
2. The minimal donor site morbidities.
3. Patient factors, such as comorbidities, compliance, and prognosis.
4. The costs of the treatment and
5. Resource utilization.

The reconstructive surgeon must systematically appraise the defect and the options available to optimize functional potential by

choosing the most appropriate reconstructive option [73].

Fedorowicz Z., *et al*. [52] found no reliable RCT evidence for medical or surgical problems caused by restricted mouth opening, and according to him, more robust trials are required to identify the most effective treatment approaches to this debilitating condition.

In the study we carried out on 25 patients, the definite protocol was followed in all patients, the surgical treatment was standardized, and all patients were followed regularly for three years.

There have been conflicting views about the use of skin grafts in the treatment of OSF. Some clinicians favor its use while others outright reject it, though few clinicians have used skin grafts to cover raw areas created in the buccal mucosa after excision of the fibrous bands of OSF**.**

According to Nanavati., *et al*. (unpublished data), only eleven studies involving 169 patients have investigated the role of STSG in the surgical management of OSF.

When used to excise intraoral lesions, skin grafts often resurface minor defects. Split skin grafts have certain advantages in covering intraoral mucosal defects. Skin grafting benefits from the ease of harvest with minimal additional operating time and postoperative hospital stay, an acceptable functional cosmetic result, and the ability to survive post-operative radiation [52] when radiation is part of the treatment. Also, using split-thickness skin grafts increases the practicability of a more exhaustive removal of abnormal mucous membranes surrounding the primary lesions [53].

Sharp and Helsper have described using skin grafts to treat intraoral cancer [54].

Yen was the first to succeed in coveting the buccal defect with a split-thickness skin graft in treating a case of oral submucous fibrosis [55].

Yeh carried out a surgical procedure of incising the mucosa down to the muscles from the angle of mouth to the anterior tonsillar pillar, taking care to prevent damage to the stoma of the parotid duct, followed by split skin grafting into the defect, with acceptable results [56].

Chen Loong Soh and M. R. Muthu Sekhar [57] reported using split skin grafts and polyethylene stents in 15 patients with OSF. They concluded that Fibrotomy followed by a split skin graft, a polyethylene sheet stent, and sufficient postoperative physiotherapy is a simple, cost-effective, and viable treatment modality for oral submucous fibrosis.

Canniff., *et al*. [58] described the procedure of split-thickness skin grafting after bilateral temporalis myotomy or coronoidectomy, along with daily opening exercise and nocturnal props for four more weeks.

We carried out split skin grafting in 25 patients, adhering to a definite protocol. The average preoperative IID was 1.49 CMS, which increased to 3.44 CMS at the end of the three years.

One of the most critical issues that concern clinicians is securing the skin graft to the recipient bed and subsequent immobilization of the graft. A few crucial issues facing clinicians when using intraoral skin grafts for OSF treatment are:

1. Reduced vascularity of the recipient bed due to fibrosis.
2. Buccal mucosa is a mobile structure.
3. Recipient bed is sometimes uneven.
4. The oral cavity is a wet structure constantly bathed in saliva.
5. Proximity of essential and sensitive structures to the surgical site.

Intraoral skin grafting in the buccal mucosa requires meticulous planning and execution, particularly regarding immobilization and skin graft adherence to the recipient bed.

Graft failure can be prevented by immobilizing the graft and closing any potential dead space that might lead to separation. Multiple approaches for immobilizing skin grafts intraorally have been described in the literature. In 1975, Goshgarian and Miller [59] described a parachute stent technique that secures intraoral skin grafts via transcutaneous sutures. In 1981, Friedlander and

Miller [60] described using eye patches and a denture soft liner to ensure the split-thickness skin graft (STSG) to the cheek using trans buccal bolster sutures. Since then, many materials have been used, including foam, gauze, sutures, silicone, foam rubber pads, eye patches, and various bolstering techniques [60,61].

The traditional tie-over-bolster technique described by Schramm and Myers involves fixation of the skin graft to the raw area, followed by placement of non-absorbable silk sutures from the adjacent mucosa, which is then tied over the bolster. However, the placement of this tie over sutures requires adjacent normal mucosa for anchorage, which may not be sufficient, especially in the gingiva-buccal sulcus. Although external fixation of the stents to the cheek has been described, this results in ugly scaring of the cheek [52].

In our surgical technique, these problems were overcome by giving the recipient site a proper rectangular shape with adequate tissue surrounding it, using multiple interrupted absorbable sutures, tie-over bolster dressings, and using the softened dental compound on the graft between teeth so that sufficient pressure is created on the graft and oral movements are restricted.

Improved oral opening is an essential objective of OSF treatment. The treatment of severe trismus requires a combination of surgical release and postsurgical physiotherapy; the latter is critical for preventing relapses due to postoperative inactivity and scarring [62-68]. Mouth exercising is a well-established method to improve mouth opening and prevent post-surgical relapses. Various devices that help patients improve their mouth opening have been described in the literature. Most appliances are tooth-borne, where opening force can be applied with the help of the devices or stents placed between the maxillary and mandibular arches or teeth. The main objective of OSF is to improve mouth opening. Previous literature described many mouth-opening devices [65-67]. Cox and Zoellner [65] tested the hypothesis that physiotherapy alone can modify tissue remodeling in OSF to increase oral opening. Mouth-opening devices are fixed to the teeth to keep the dental arches apart [65,66]. Partially or edentulous arches, decayed teeth, or periodontitis do not allow for such devices, and often, patients suffering from severe trismus present with these conditions. A non–tooth-borne mouth-opening device applying force to two intraoral screws placed in the vestibule of the maxillary and mandibular bones is described in such a situation. Patient noncompliance prevents surgical intervention for the placement of the screws and limits the use of such devices. Patil and Patil [64] describe the fabrication and use of a new mouth-exercising device (MED) that helps patients squeeze or stretch the cheek, resulting in local tissue remodeling to increase the elasticity of the mucosa for improvement in mouth opening [64].

Despite tremendous advances in oral physiotherapy devices [64], economic conditions and restricted resources make clinicians use their own indigenously made oral physiotherapy devices. We gave patients wooden oral stents (Props) of increasing lengths, like 2.5, 2.8, and 3.00 cm, and advised them to insert them between their teeth as long as possible until they fall off and do not stay between them because of increased mouth opening. The patient will then start using a longer stent until he reaches the most extended stent.

Generally, IID is considered a parameter of success in the surgical treatment of trismus associated with OSF. Accordingly, we measured IID at the end of a one-month and six-month period and one-year, two-year, and three-year period. All patients were recalled accordingly, IID was measured, and a clinical examination was conducted to notice any change. Patients were encouraged to continue with oral physiotherapy.

A study of the first two charts reveals that forceful mouth opening considerably improves the IID. However, surgical fibrolysis and myotomies are necessary to achieve the desired and acceptable mouth opening. The average Preop IID was enhanced from 1.49 to 2.86 CMS after forcefully opening the mouth, while after fibrolysis and myotomies, the average IID showed significant improvement from 2.86 CMS to 3.40 CMS.

At the end of one year, most graphs do not show any further contraction and remain stable, as evidenced by stability in IID measured and compared at the end of one-year, two-year, and three-year periods (Chart 1-10).

However, using skin grafts to manage trismus associated with OSF has not given some clinicians the expected or satisfactory re-

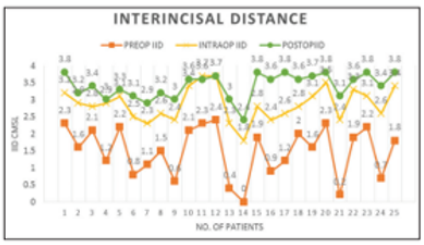


Chart 1: Inter-incisal distance (IID) pre-operative, intra-operative, and immediate post-operative

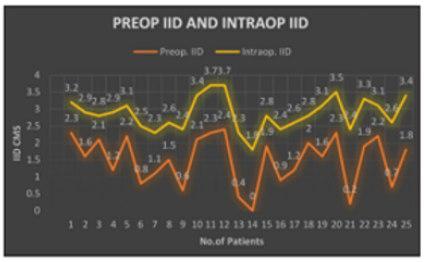


Chart 2: Pre-operative inter-incisal distance (IID) and intra-operative IID

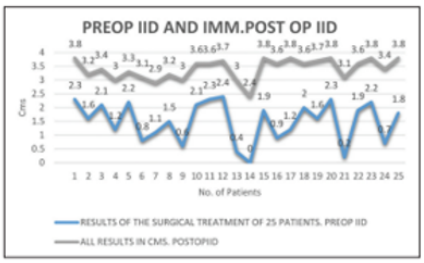


Chart 3: Pre-operative inter-incisal distance (IID) and immediate

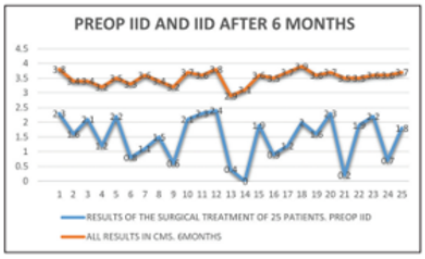


Chart 4: Pre-operative inter-incisal distance (IID) and post-operative IID after 6 months

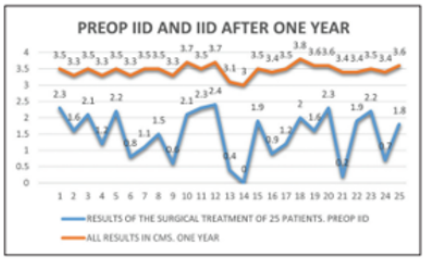


Chart 5: Pre-operative inter-incisal distance (IID) and IID after 1-year

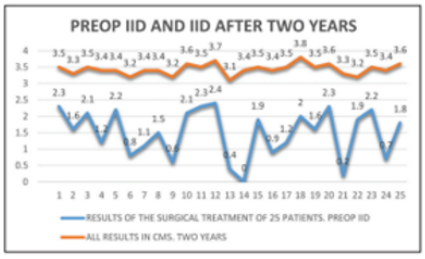


Chart 6: Pre-operative inter-incisal distance (IID) and IID after 2 years

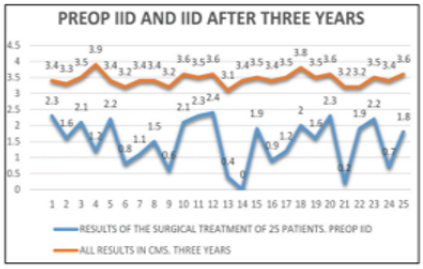


Chart 7: Pre-operative inter-incisal distance (IID) and IID after 3 years

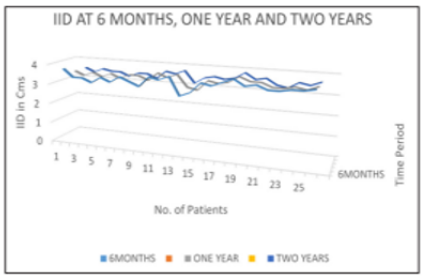


Chart 8: Inter-incisal distance after 6 months, 1 and 2 years

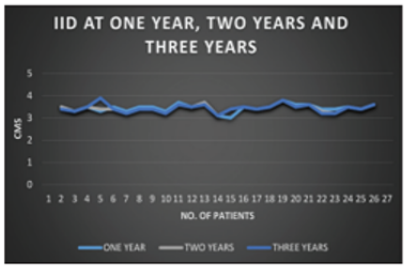


Chart 9: Inter-incisal distance at the end of 1, 2, and 3 years period

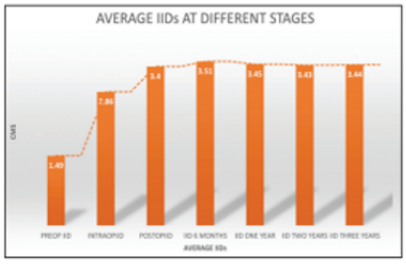


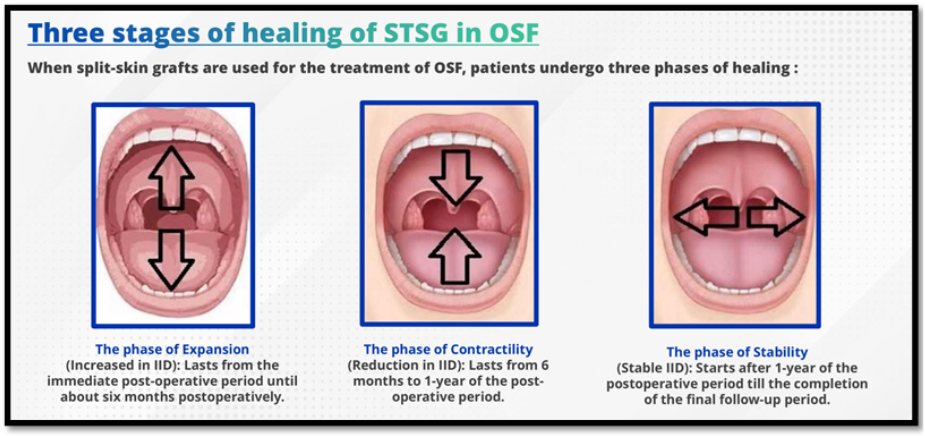
Chart 10: Average inter-incisal distances (IIDs) at different stages

sults. Few clinicians have outright rejected skin grafts as a suitable replacement tissue for significant buccal defects created after fibrous band excision; it is vital to excise fibrous bands (Fibrolysis) and not cutting fibrous bands (Fibrotomy). We believe that proper surgical technique and meticulous follow-up of the patients for long periods give good results, as has been given to our patients. We have also proposed a protocol for using skin grafts in OSF.

When split-skin grafts are used for the treatment of OSF, patients undergo three phases of healing (Figure 5):

1. Phase of expansion: (Increased in IID) In this phase, the patient experiences increased mouth opening post-operatively because of surgical fibrolysis and myotomies followed by intense oral physiotherapy by the patient. This phase lasts from the immediate postoperative period till six months postoperatively (Chart 1 to 4).
2. Phase of contractility: (Reduction in IID) In this phase, the patient shows a reduction in mouth opening due to normal wound and skin graft contracture during the healing phase. Another possibility is the non-cooperation of the patient regarding tobacco habits or oral physiotherapy. This phase lasts from 6 months to one year of the postoperative period (Chart 5 to 7).
3. Phase of stability: (Stable IID) This is the final phase in which the wound and skin grafts stabilize without further contracture. IID remains constant, and the patient shows signs of cooperation. This period usually starts after one year of the postoperative period till the final follow-up, in our case, three years (Chart 8 to 10).

Figure No. 5: Three stages of healing of STSG in OSF



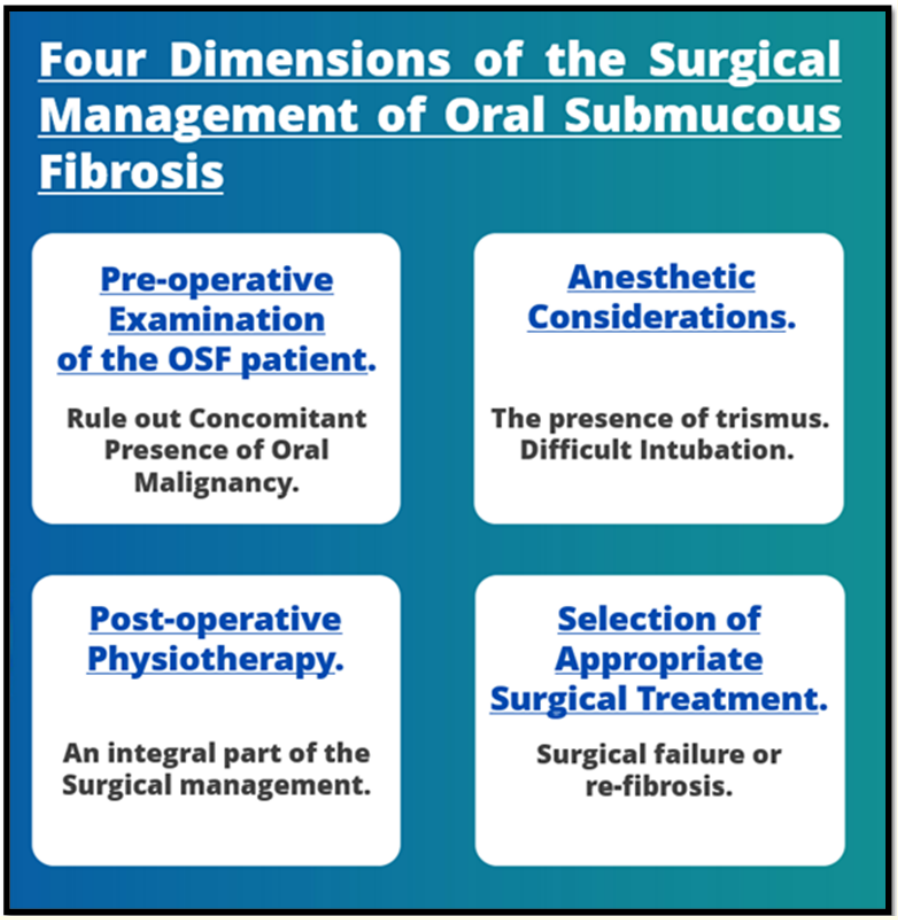
Figures illustrating patients' pre-operative and post-operative surgical outcomes using split-thickness skin grafts in OSF are presented in figure 6. We got good results by using split skin grafts in OSF. Statistically, results were significant with $P < 0.05$ (ANOVA Single Factor 6.3521E-38). IBM Watson Analytics showed high-quality results with 93 points.

We believe that the choice of surgical interventions while treating trismus in OSF clinicians should bear in mind the necessity of repeat surgery in case of surgical failure or re-fibrosis and trismus following the inability of patient compliance as regards the stoppage of tobacco habit and oral physiotherapy. Unfortunately, most surgeries advocated by various clinicians fail on both these accounts. Repeat surgeries are not possible using the same local or distant tissue flaps, and therefore, more radical surgery needs to be undertaken, for which the patient may not agree and may not be possible. When re-fibrosis occurs, intraoral local flaps like Palatal Island or tongue flaps are known to get fibrosed. Skin grafts allow repeat surgery in case of surgical failure or re-fibrosis.

Figure No. 6: Pre and Postoperative results

Four dimensions of the surgical treatment of OSF (Figure 7)

Figure No. 7: Four Dimensions of the Surgical Management of Oral Submucous Fibrosis



Pre-operative examination of the patient

Kishore Sandu and SM Makharia [70] suggest that the following diagnostic procedures be carried out before any surgical intervention in OSF patients is contemplated:

1. The treating surgeon must always suspect an underlying concomitant malignancy while treating oral submucous fibrosis. One must keep in mind that carcinogenic substances are the same as those causing OSF and Oral cancers. Concomitant oral malignancy diagnosis may be difficult, primarily when the patient has associated with restricted mouth opening and negative neck metastasis.
2. Flexible endo laryngoscopy would be diagnostic in lesions involving the oropharynx and in nasotracheal intubations, though it still does not help diagnose lesions of the mobile anterior tongue. Flexible Laryngoscopes may also not be available at all centers, so these patients require greater caution during general anesthesia induction.
3. Preoperative barium swallow and an orthopantomogram (or X-ray mandible) should become part of these patients' routine work. Such investigations are undoubtedly helpful, though diagnosing a submucosal lesion may still be challenging.

4. Once a satisfactory mouth opening is achieved, a thorough examination under anesthesia to pick up any underlying induration/submucosal lesion completes the oral examination.
5. An MRI of OSF with severe trismus needs attention, and this investigation would be necessary for diagnostic armamentarium [70].

The surgical treatment plan may need modification in the altered circumstances.

Selection of appropriate surgical treatment

Surprisingly, the subject of surgical failure or re-fibrosis of the oral tissues due to various reasons in OSF's surgical management has still not been comprehensively investigated. The need for secondary surgery in OSF has received scant attention in the research literature on OSF.

Intraoral tissue flaps [e.g. Tongue and Palatal Flaps] may not be possible because of preexisting fibrosis, or these flaps themselves get fibrosed in the event of patient non-compliance, making their re-use obsolete. Extraoral tissue flaps have inherent disadvantages [e.g. they are technically challenging, may need additional training, and leave behind massive facial scars that may not be acceptable to the patient]. The existing accounts on using extraoral local flaps in OSF fail to resolve the surgical failure and re-fibrosis issues as their re-use is obsolete.

Local flaps are currently considered the main reconstructive option for medium-size oral and perioral defects; however, their indications are sometimes challenging to select. The study carried out by Comini LV., *et al*. was to analyze their selection and critically propose a therapeutic algorithm [71].

The following criteria need to be considered:

1. The defect's location: Surgical treatment of OSF involves creating a significant defect in the cheek mucosa because of the excision of fibrous bands followed by covering the defect with the appropriate material.
2. Characteristics of defects: influenced by size and sub-site of the defect, the natures of different tissues involved (skin only/mucosal layer or deep tissue and bone involvement), and the associated functional impairment
3. Patients' clinical factors: focus on each patient's clinical parameters and final expectations [71].

The main functional aspects that deserve to be preserved are as follows:

1. Oral competence and sufficient oral access,
2. Tongue mobility,
3. Intelligible speech,
4. Swallowing and
5. Separation of the oral cavity from the nose, nasal sinus, and neck.
6. Microstomia should be limited,
7. Preserving the whole orbicularis oris muscle as it plays a crucial role in oral competence [23].

To ensure adequate aesthetic and functional results, it is advisable to precisely and carefully plan the most suitable reconstruction flap according to the defect's location [71].

Post-operative physiotherapy

Postoperative oral physiotherapy in forceful mouth opening is an integral part of OSF treatment, irrespective of the type of surgical treatment. Without such maneuvers, the surgical treatment of OSF fails to give the desired results. Every surgeon has used traditional mouth-opening devices like Heister's appliance or has developed various devices or splints for this purpose, depending on the circumstances.

Anesthetic considerations

Surgical treatment of patients with OSF not only demands high standards of skills from the surgeon but also anesthesiologists because of two significant factors:

1. The presence of trismus because of fibrosis leads to complex airway management and
2. The compromised general health of the patients in the presence of areca nut and tobacco addiction and nutritional deficiency.

According to Eipe Naveen [72], numerous practice guidelines have been developed to help clinicians manage the difficult air-

way. However, the nature of complex airway management does not provide a practical way of comparing different guidelines or algorithms; no evidence supports one set of instructions over another. Nevertheless, they play a significant role in patient safety as disseminating such guidelines encourages airway practitioners to consider their strategies and formulate concrete plans to manage a predicted or unexpectedly difficult airway. Anesthesiologists should have a high degree of suspicion and carefully examine the airway of patients who abuse betel quid. The resulting trismus and IID have been used to classify patients into mild (IID > 20 mm) and severe (IID < 15 mm) OSF. This classification may be misleading for anesthesiologists, as an IID of at least 30 mm is required for direct laryngoscopy, and patients with "mild OSF" may still be difficult to intubate. "Preliminary laryngoscopy" under anesthesia is valuable and should be reserved for patients with adequate mouth opening. Airway management in OSF depends on the expertise and available equipment. Blind nasal or retrograde techniques may be used, although fiber-optic intubation is the method of choice. Tracheostomy under local anesthesia is to be resorted to if the former is unavailable or fails [72].

How split skin graft prevents or minimizes re-fibrosis is a question of debate.

Wound healing and scar formation are highly complex processes that involve Actin, myosin, and tethering movements of fibroblasts and myofibroblasts.

Scar contracture is putatively caused by fibroblast and myofibroblast contractility during the remodeling phase of repair. However, it is unclear which myosins are activated in fibroblasts and myofibroblasts and how they are regulated to increase tractional force generation and promote tissue remodeling. Current hypotheses suggest that tractional force generation within these cells and subsequent scar contracture formation is primarily caused by myosin II activation and ensuing actin stress fiber formation, focal adhesion development, and cytoskeletal (microtubules and intermediate filaments) reorganization. The current hypothesis is that fibroblasts become activated and transition into proto-myofibroblasts and myofibroblasts [69].

Based on the above description of scar contracture, we suggest a hypothesis that skin graft prevents or minimizes re-fibrosis by following three mechanisms (Figure 8 and 9):

Figure No.8: The role of STSG in prevention or minimizing re-fibrosis

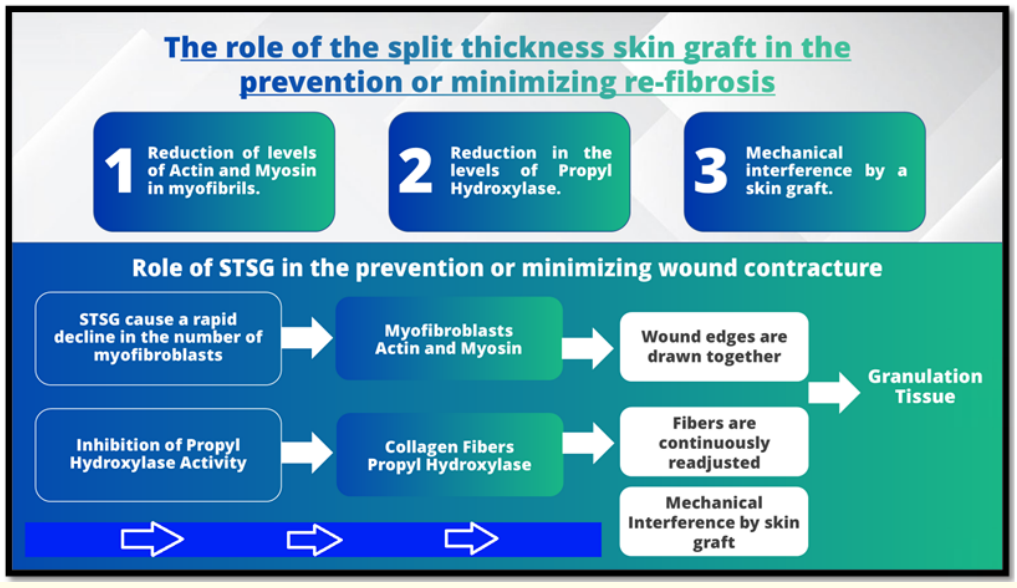
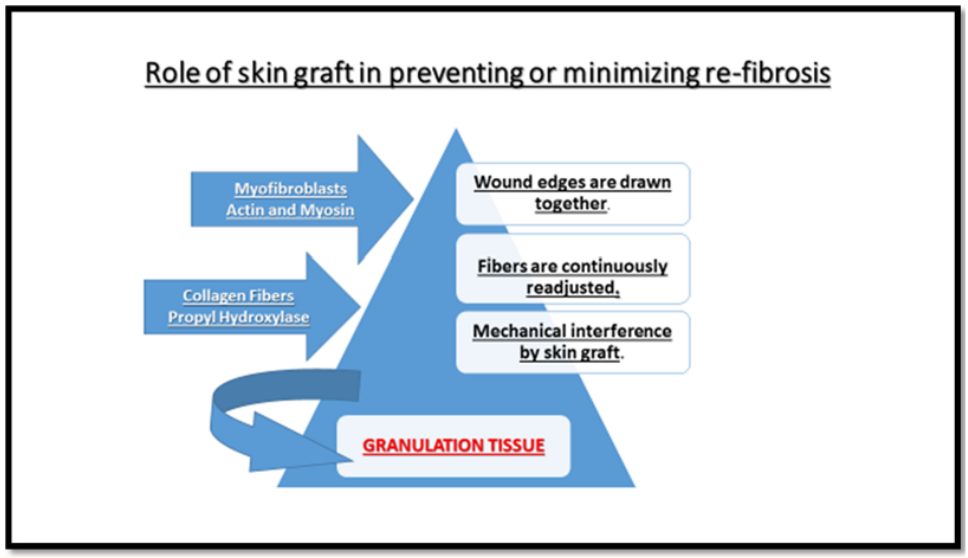


Figure No. 9: Role of STSG in preventing or minimizing re-fibrosis in OSF



1. Reduction of levels of Actin and Myosin in myofibrils.
2. Reduction in the levels of Propyl Hydroxylase.
3. Mechanical interference by skin graft.

However, further studies are necessary to arrive at any definite conclusions.

Conclusion

Surgical treatment of trismus associated with OSF is challenging and needs meticulous planning and execution. Proper choice of surgical intervention is necessary considering surgical failure or re-fibrosis. We have proposed using split skin grafts in treating trismus associated with OSF and have obtained good results (p-value < 0.05). We have also proposed a protocol to follow while using skin grafts in OSF, healing stages that occur in the patients when skin grafts are used and have suggested a hypothesis regarding the mechanism of how skin grafts prevent or minimize re-fibrosis (Figure 10).

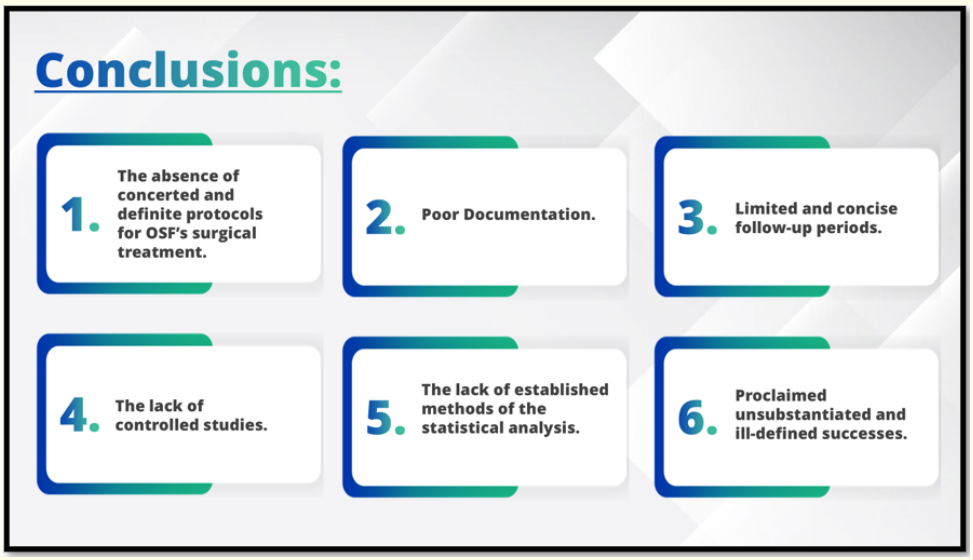


Figure 10

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