Original Article

A fascia bow traction method for the treatment of unilateral marginal mandibular nerve paralysis after mandibulectomy for head and neck cancer

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\textbf{ABSTRACT}

\textit{Background:} Unilateral paralysis of the marginal mandibular nerve (UPMMN) after head and neck cancer surgery is a relatively common condition that causes deformity and an asymmetric appearance of the lower lip and impairs the quality of life of patients. We developed a novel fascia grafting method to improve the appearance of the lower lip in patients with UPMMN.

\textit{Methods:} Two fascia strips and a small fascia loop connecting the two strips are used: one is fixed horizontally to pull the lower lip toward the paralyzed side, and the other is fixed in a bow shape at rest to avoid approaching the lateral mandibular margin. When patients smile or open their mouths, the bow-shaped graft straightens, pulling the paralyzed lower lip laterally downward through the small connecting loop. We used this method to treat four patients with UPMMN who had undergone head and neck cancer ablation. The symmetry and movement of the lower lip were assessed using preoperative and postoperative photographs of three poses (at rest, smiling, and opening the mouth).

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https://doi.org/10.1016/j.jpra.2022.07.004
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Results: The fascia grafting procedure restored the symmetry of the lower lip at rest and greatly improved symmetrical lower lip movement when smiling and opening the mouth. According to photographic evaluation scores, all patients had poor lower lip symmetry in the three poses before the procedure, whereas after the procedure, three had excellent lower lip symmetry, and one had good lower lip symmetry. There was a significant difference between the scores before and after the surgery.

Conclusions: Fascia grafting is easy and minimally invasive, allows patients to generate an almost symmetrical smile, and consequently improves their QOL. This method may be particularly useful when the lateral mandibular bone is resected during cancer surgery, and the defect is reconstructed with metal plates/soft tissue, as the method does not require approaching the lateral mandibular region.

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Introduction

The marginal mandibular nerve (MMN), a terminal branch of the extracranial part of the facial nerve, is located below the mandibular bone proximal to the mandibular angle. It runs upward to the lower lip just anterior to the mandibular angle and innervates the lower lip depressor muscles. Since, in most cases, the nerve is not a part of network with other branches of the facial nerve,1 it is vulnerable to injury and is sometimes sacrificed inadvertently or intentionally during head and neck cancer surgery.

Unilateral paralysis of the marginal mandibular nerve (UPMMN) after head and neck cancer surgery can cause a unique, asymmetrical lower lip deformity2, which is referred to as a marginal mandibular lip deformity.3,4 The deformity worsens when patients smile or open their mouths wide. The platysma muscle which pulls the lower lip downward and laterally can be denervated during neck dissection, which exacerbates the lower lip deformity.5

Natural and symmetrical movements of the lower lip, including smiling, are important for improving the quality of life (QOL).6 Restoring symmetrical lower lip movement can increase the QOL of patients after head and neck cancer surgery.7-9 Since patients with head and neck cancer are usually old and sometimes in poor condition, a simple and minimally invasive method to treat UPMMN is desirable.10,11 We developed a novel fascia grafting method to improve symmetrical lower lip movement using a horizontally positioned fascia strip graft (horizontal graft), a bow-shaped graft (bow graft), and a small fascia loop connecting the two grafts. This method differs from other conventional fascial grafting methods which require approaching the lateral mandibular margin. Approaching the lateral mandibular margin is neither desirable nor feasible in patients who have undergone mandibular bone resection and had the defect reconstructed with metal plates/soft tissue. The principle of our method is that the small loop connecting the two fascial grafts pulls the horizontal graft laterally downward when the bow graft stretches and straightens from its relaxed position. Since the force to pull the bow graft laterally upward is converted into a force acting at a right angle to the bow graft and provides traction to the lower lip through the small loop and the horizontal graft, mimicking lower lip depressor contraction, we named this method “the fascia bow traction method.”

We used this method to treat four patients with UPMMN after head and neck cancer surgery and describe our experiences.
Patients and methods

The fascia bow traction method was performed in four patients who developed UPMMN after head and neck cancer surgery. Two patients had squamous cell carcinoma (SCC) involving the buccal mucosa. Following cancer ablation with marginal mandibulectomy, defects were reconstructed using forearm flaps and plates. The other two patients had SCC in the mandibular bone and gingivae. Following cancer ablation with segmental mandibulectomy, defects were reconstructed using fibular flaps. All patients had suffered from UPMMN for more than six months (range: 6–19 months) postoperatively. Patient characteristics are shown in Table 1.

Operative technique

The procedure was performed under general anesthesia through nasal intubation. Preoperatively, the distance between the midline of the lower lip and that of the upper lip (i.e., the midline of the face) was measured. The lower lip was shifted to the non-paralyzed side when the patient was awake, but the shift usually disappeared under general anesthesia.

Two fascia strips roughly 15 cm in length and 7 mm in width, and a small fascia loop roughly 1 cm in length and 7 mm in width, were harvested from the tensor fascia lata. Two small vertical incisions were made on the vermilion of the lower lip (Points A and A'), at the position that divides the lip into three equal parts. A subcutaneous tunnel was created from Point A to Point A' and to the labial commissure on the paralyzed side. The tunnel was extended in a slightly upward direction to the anterior edge of the masseter muscle (Point C). One fascia strip was passed through the tunnel from Point A to Point C (horizontal graft; Fig. 1), with one of its ends sutured to the orbicularis oris muscle at Point A. The fascia loop was passed around the horizontal graft at Point A' (Fig. 1, top center), with both ends sutured to the other fascia strip (Fig. 1, top right), allowing it to freely move around the horizontal graft during surgery.

Next, the labial commissure on the paralyzed side was sutured to the horizontal graft in a slightly overcorrected position, pulling the midpoint of the lower lip to the paralyzed side as much as the distance of the midline of the lower lip from the midline of the face which was measured before the surgery. The midline scar from the previous cancer surgery in the mandibular region was excised. Another subcutaneous tunnel was created from the midpoint of the lower edge of the mandible (Point B) to Point A', the nasolabial fold, and finally to the anterior edge of the masseter muscle. One end of the second graft, to which the fascia loop was sutured, was fixed to the periosteum of the midpoint of the lower edge of the mandible (Point B; Fig. 6, bottom left). The horizontal graft was sutured to the dermis of the nasolabial fold through a small skin incision, and the free end of the graft was sutured to the anterior edge of the masseter muscle (Point C) in a slightly overcorrected position (Fig. 6, bottom center). The second graft was passed through the tunnel from Point B to Point A' and then through the subcutaneous tunnel from Point A' to the anterior edge of the masseter muscle.

After confirming that the length of the second graft was sufficient to allow for a full smile and maximum mouth opening, the free end of the second graft was sutured to the anterior edge of the masseter muscle, slightly below Point C (Point C'), and the dermis of the nasolabial fold was sutured to the second graft through a small skin incision (Fig 1, bottom center). The second graft is bow-shaped at rest and is thus referred to as the “bow graft.” All grafts were sutured with 4-0 clear nylon sutures (non-absorbable sutures).

The lower lip symmetry at rest without the effect of general anesthesia was restored by the horizontal graft. The bow graft is loose at rest (like a bow) but straightens when the patient makes a full smile or widely opens the mouth. As the midpoint of the bow graft moves laterally downward when stretched, the horizontal graft is pulled laterally downward at Point A' through the loop (Fig. 1, bottom right). This mechanism is expected to improve the symmetry of the lower lip movement during smiling and mouth opening.

Photographic evaluation

Lower lip symmetry in three poses (at rest, smiling, and mouth opening) was assessed using pre-operative and postoperative photographs by six evaluators (one clerk, one nurse, two surgical trainees,
Table 1
Patient characteristics

| Patient no. | Age/sex | Diagnosis | Cancer site | Flap used for reconstruction | Mechanism of MMN injury | Duration between cancer surgery and fascia grafting (mo) | Preoperative evaluation (mean TS) | Postoperative evaluation (mean TS) | Follow-up period (mo) |
|-------------|---------|-----------|-------------|-----------------------------|------------------------|----------------------------------------------------------|---------------------------------|----------------------------------|---------------------|
| 1           | 57/M    | SCC       | Lt Buccal   | Forearm flap                | Tumor involvement      | 19                                                       | Poor (0.50±0.55)                | Excellent (6.67±0.82)          | 24                  |
| 2           | 59/F    | SCC       | Lt Buccal   | Forearm flap                | Tumor involvement      | 6                                                        | Poor (0.65±0.75)                | Good (5.83±0.75)          | 103                 |
| 3           | 76/F    | SCC       | Rt Mandible | Fibular flap                | Tumor involvement      | 14                                                       | Poor (0.33±0.52)                | Excellent (6.67±0.82)          | 62                  |
| 4           | 70/M    | SCC       | Lt Mandible | Fibular flap                | Tumor involvement      | 15                                                       | Poor (0.67±0.52)                | Excellent (6.50±0.55)          | 41                  |

Note: SCC: squamous cell carcinoma, MMN: marginal mandibular branch of facial nerve TS: total score
Evaluation was assessed by photograph evaluation score (Table 2)
Figure 1. Diagram of the procedure. (Top left) Points A and A' horizontally divide the lower lip into three equal sections. A fascia strip (horizontal graft) is sutured to the orbicularis oris muscle of the lower lip at Point A. Point A is on the non-paralyzed side, and Point A' is on the paralyzed side. (Top center) A small fascia loop is passed around the horizontal graft at Point A. (Top right) Both ends of the small fascia loop are sutured to a second fascia strip at Point A'. The loop can move freely around the first strip (horizontal graft).(Bottom left) The horizontal graft is sutured to the labial commissure on the paralyzed side in a slightly overcorrected position. One end of the second fascia graft (bow graft), to which the small loop is sutured, is fixed to the midpoint of the lower edge of the mandible through a subcutaneous tunnel (Point B). Then, the graft is passed through the subcutaneous tunnel to Point A', the nasolabial fold, and finally to the anterior edge of the masseter muscle. (Bottom center) Next, the free end of the horizontal graft is sutured to the anterior edge of the masseter muscle (Point C) and the dermis of the nasolabial fold. The free end of the bow graft is sutured to the anterior edge of the masseter muscle, slightly below Point C; it is also sutured to the dermis of the nasolabial fold.(Bottom right) The bow graft is stretched during full smiling and maximum mouth opening movements. Because the midpoint of the bow graft is moved laterally downward when stretched, the horizontal graft is pulled laterally downward at Point A' through the small fascia loop. Bottom center and bottom right panels show the appearance of the lower lip without the influence of general anesthesia. Under general anesthesia, the midline of the lower lip was shifted to the paralyzed side due to overcorrection; after recovery from the anesthesia, however, the lower lip symmetry at rest was restored.

one plastic surgeon, and one maxillofacial surgeon). Preoperative and postoperative photographs were taken one day before and ≥6 months after fascia grafting, respectively, with patients at rest, smiling, and opening the mouth maximally. We first tried to examine operative results according to three types of smiles described by Rubin, namely, the “Mona Lisa” smile, “canine” smile, and “full denture” smile, on a 0–3-point scale. However, since not all patients were able to achieve the three smile poses due to the extent of tissue invasion from cancer surgery, we used a simple, modified method to assess lower lip appearance during movement. Specifically, when the patient could not make a “full denture” smile, lower scores (0–2 points) were assigned to the other two smiles (“canine” and “Mona Lisa” smiles) as shown in Table 2. This is because the “full denture” smile is generally most affected by UPMMN. The mean total score was calculated to assess the lower lip symmetry in three poses as excellent, good, fair, or poor (Table 2).

All clinical information was collected after obtaining written informed consent from patients. This study was approved by the institutional review board of the National Hospital Organization, Osaka National Hospital (IRB No: 21-098). None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript.
Table 2
Photograph-based evaluation score.

| Status                        | No asymmetry | Mild asymmetry | Moderate asymmetry | Severe asymmetry |
|-------------------------------|--------------|----------------|-------------------|------------------|
| 1) At rest                    | 2            | 1              | 0                 | 0                |
| 2) Opening the mouth maximumly| 3            | 2              | 1                 | 0                |
| 3) Smile a) When “full denture” smile is possible “Full denture” smile | 3            | 2              | 1                 | 0                |
| b) When “full denture” smile is not possible “Mona-Lisa” smile or “canine” smile | 2            | 1              | 0                 | 0                |

Note: Total score (TS) was calculated as the sum of (1), (2), and (3) (a or b)
Poor, 0 ≤ mean TS < 2; Fair, 2 ≤ mean TS < 4; Good, 4 ≤ mean TS < 6; Excellent, 6 ≤ mean TS ≤ 8

Figure 2. Preoperative and postoperative images of patient 3. (Top) Preoperative view. A 76-year-old woman with UMMN at one year and three months after cancer surgery. The previous cancer surgery resulted in an unsightly midline scar in the mandibular region and typical marginal mandibular lip deformity. (Top left) The lower lip was shifted to the non-paralyzed side at rest. (Top center) Lower lip deformity worsened when smiling. (Top right) During maximum mouth opening, the lower lip appeared asymmetrical and shifted to the non-paralyzed side. (Bottom) Postoperative view at two years and three months after the fascia grafting procedure. (Bottom left) The lower lip appeared symmetrical at rest. (Bottom center and left) Lower lip symmetry was greatly improved during smiling and maximum mouth opening. (Bottom center) She was able to make the symmetrical “full denture” smile. The midline scar was repaired.

Results

Photographic evaluation scores

The scores of preoperative and postoperative photographic evaluations of the four patients who underwent treatment with the fascia bow traction method are summarized in Table 2.

According to these scores, all four patients had poor lower lip symmetry in three poses before the procedure, whereas after the procedure, three had excellent lower lip symmetry, and one had good lower lip symmetry (Table 1). There was a significant difference between the scores before and after surgery (p = 0.00287, paired t-test.)

Case report

Representative cases (patient 3; Table 1) are described below.
A 76-year-old woman (patient 3) underwent wide excision of SCC involving the right mandible (T2N1M0), including a segmental resection of the right mandibular bone, sacrifice of the right MMN, and a vertical skin incision along the midline of the mandible with right radical neck dissection. The defect was reconstructed with a free fibular flap. The skin paddle of the flap was largely de-epithelialized and used to completely cover the fibular bone and mini-plates, which was also expected to add some volume for improved appearance. She suffered from residual paralysis of the right MMN for more than one year after cancer surgery (Fig. 2, top). She had cosmetic and functional problems of the lower lip (i.e., asymmetrical disfigurement of the lower lip and a slight difficulty in speaking), as she often bit the lower lip from inappropriate contact between the upper teeth and the lower lip on the paralyzed side.

We performed the fascia bow graft method to improve the appearance and function of the lower lip one year and two months after cancer surgery. Postoperatively, the symmetry of the lower lip at rest was restored (Fig. 2, bottom left), and the symmetrical lower lip movement while smiling or opening the mouth was greatly improved (Fig. 2 bottom center and left). She was able to make the symmetrical “full denture” smile (Fig. 2, bottom center). The photographic evaluation improved from poor (mean total score: 0.33±0.52) preoperatively to excellent (6.67±0.82) postoperatively. In addition to favorable cosmetic outcomes, the correction of the deformity led to the avoidance of inappropriate contact between the upper teeth and the lower lip on the paralyzed side, thereby improving her speech ability.

Discussion

We developed a novel fascia grafting method to treat the mandibular lip deformity resulting from UPMMN after head and neck cancer surgery. Simple and minimally invasive methods are desirable for correcting UPMMN after head and neck cancer surgery. A number of minimally invasive techniques for correcting UPMMN have been reported,10,11,12–25 which are largely categorized into the following three groups: (1) partial resection of the lower lip tissue on the normal side4,21 (e.g., resection/denervation of the lower lip depressor muscles) or the paralyzed side3,19 (2) transfer of the anterior belly of the digastric muscle,14,20 and (3) fascia or tendon grafting without sacrificing lower lip tissue.10,11,22–25

Resection or denervation of the lower lip depressor muscles on the normal side is a simple and minimally invasive method for restoring lower lip symmetry.4,21 However, this procedure can further weaken lower lip function and may even result in significant oral incompetence, particularly after extensive cancer surgery. Partial lower lip resection on the paralyzed side also is prone to the same problem.3,19 Thus, these approaches are not desirable for patients after head and neck cancer surgery.

Transfer of the anterior belly of the digastric muscle offers an effective and relatively less-invasive option.14,20 but the muscle is often sacrificed during head and neck cancer surgery.

Fascia or tendon grafting is performed as yet another simple and minimally invasive alternative. Fascia lata slings have been widely used for static reconstruction in cases of facial palsy.10,11,22–25 This approach is effective in most cases except for those of marginal mandibular branch palsy. However, the movement of the lower lip depressor usually cannot be restored with only these usual fascia grafting. In other words, patients do not recover the ability to make the full denture smile or achieve the symmetrical appearance of the lower lip when mouth opening with most of these usual fascia grafting methods.

Rose et al. reported excellent results of platysma transfer/autogenous fascia lata extension for lower lip depressor weakness.25 The movement of voluntary lower lip depressor contraction could be mimicked with the transferred platysma muscle, allowing for the full denture smile. However, since the platysma muscle is sacrificed during surgery in most patients with head and neck cancer, this platysma transferring method is usually not applicable.

Double fascia grafting is particularly effective for improving the appearance of the lower lip during mouth opening and smiling movements.10,11 This method does not require muscle transfer and uses only fascia grafting. When applying this method to patients with head and neck cancer, however, one shortcoming is that the fascia graft is sutured to the lower edge of the lateral mandibular bone to provide a downward force to the paralyzed lower lip. After marginal or segmental mandibulectomy,
the lateral mandibular defect is sometimes reconstructed with a titanium reconstructive plate, which is vulnerable to infection or exposure or with soft tissue only. Approaching the lateral mandibular margin is thus neither desirable nor feasible in such cases.

To address this issue, we developed the fascia bow traction method, in which a horizontal graft is fixed in the almost same manner as in the case of the double fascia graft method, while a second fascia graft (bow graft) is sutured to the midpoint of the mandibular margin, the dermis of the nasolabial fold, and the anterior edge of the masseter muscle to form a bow shape at rest.

Although our method does not allow for recovery of voluntary contraction of the lower lip depressor, it can achieve the symmetrical “full denture” smile or canine smile as well as the symmetrical lower lip appearance when opening the mouth. When smiling or opening the mouth, the bow graft provides the downward movement of the lower lip required for the full denture smile (mimicking lower lip depressor contraction) just as well as the double fascia grafting method does. Furthermore, since the extent of the downward movement provided by the bow graft is proportional to the extent of the upper and outward movement of the oral commissure, we believe that a more natural smiling movement can be achieved than that of double fascia grafting method.

We aim to obtain a symmetrical smile appearance, rather than a symmetrical full mouth opening appearance, as we consider that the restoration of symmetry during smiling is more important than the restoration of symmetry during full mouth opening for the QOL of patients. For this reason, the lower lip may appear slightly overcorrected as it is pulled to the paralyzed side during maximum mouth opening. Although the QOL of patients was not evaluated in this study, patient satisfaction is an important aspect that warrants further investigation.

In summary, we described the fascia bow traction method for repairing lower lip deformity due to UPMMN after head and neck cancer surgery. This method is easy and minimally invasive and provides a natural and almost symmetrical smile appearance which will consequently improve the QOL of patients. Some patients even showed improved speech ability, as inappropriate contact between the upper teeth and the lower lip on the paralyzed side can be avoided. This approach is feasible in patients for whom the usual double fascia graft method cannot be performed due to difficulty in approaching the lateral mandibular bone after lateral mandibulectomy and reconstruction with metal plates/soft tissue. The method may be particularly useful when lateral mandibulectomy is performed during cancer surgery.

**Financial Disclosure Statement**

None

**Conflict of Interest**

None

**Consent/Ethics approval**

Written informed consent was obtained from all patients. This study was approved by the institutional review board of the National Hospital Organization, Osaka National Hospital (IRB No: 20074)

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