Depressor labii inferioris resection: an effective treatment for marginal mandibular nerve paralysis

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Summary In patients who show their lower teeth during smiling and facial animation, paralysis of the marginal mandibular nerve (MMN) causes a noticeable asymmetry of the lower lip due to the absence of depressor function. This paper presents a balancing technique for this lower lip asymmetry that involves resection of the depressor labii inferioris (DLI) on the nonparalysed side. The anatomy of the muscle, the operative technique, and the effectiveness of the procedure are outlined.

A retrospective chart review was performed for 42 adult patients who were treated for MMN palsy with a DLI resection. Seven cases had only the MMN involved, and 35 cases had unilateral facial nerve paralysis. Thirty-six of these patients were available for a follow-up telephone survey.

Of the 42 primary DLI resections performed, 36 cases had successful outcomes. Of the six patients who failed to achieve the expected results, five patients had repeat DLI resection and three of these achieved the desired result; the other two patients required a third resection. One patient continued to have DLI action with smiling and subsequently had a Botox injection into the DLI with good results.

Of the 36 survey respondents, 21 patients felt their lower lip was asymmetrical at rest prior to DLI resection and 18 of these patients were improved by the procedure ($P = 0.0001$). Twenty-nine of the 36 patients reported that their lower lip was more symmetrical when they smiled following the DLI resection ($P < 0.0001$). The bilateral lack of movement in the lower lip when expressing emotions, such as anger and sorrow, was not as important to the patient as the lack of symmetry when expressing these emotions. Patients’ speech either improved or showed no change, the amount patients bit their lower lip significantly improved ($P = 0.07$) whereas oral continence showed no significant changes ($P = 0.147$) following the DLI resection.

DLI resection is a simple and effective procedure for the treatment of MMN palsy. The results are permanent and predictable. Lower lip symmetry is produced both at rest and with facial animation, without causing a functional deficit. The expected results of surgery can be trialed by local anaesthetic or botulinum toxin to block the activity of the DLI.

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The marginal mandibular nerve (MMN) is responsible for the innervation of the lower lip musculature.\(^1\) Paralysis of the MMN creates an aesthetic problem and may occur in isolation or as part of a unilateral facial nerve paralysis. Isolated paralysis of the MMN may be congenital or caused by trauma to the nerve. The nerve is frequently at risk during many surgical procedures such as meloplasty, submandibular gland resection, and neck dissection. The nerve commonly consists of two to three terminal branches of the facial nerve.\(^2\) Secondary repair of the nerve is difficult and the results are unpredictable. Following free muscle transfer for smile reconstruction in unilateral facial paralysis, often the most obvious deficit when smiling is asymmetry of the lower lip due to absence of depressor function.

Paralysis of the MMN results in the inability to depress, lateralise, and evert the lower lip. These movements are created by the actions of the lower lip depressors, consisting of depressor labii inferioris (DLI), depressor anguli oris (DAO), and to a smaller degree platysma. Of these, the most important is the DLI. The antagonist to the depressor musculature is the orbicularis oris. Sometimes the orbicularis oris is also primarily controlled by the MMN and is significantly weakened, resulting in half of the lower lip being flaccid. This results in a stretched appearance to half of the lower lip. The function of the mentalis is to elevate the lower lip and close the buccal space.\(^3\)

In MMN paralysis, when the lower lip is at rest, both sides will usually appear symmetrical, however, the paralysed side may adopt a higher position with the vermilion rolled inwards. With animation, particularly smiling, showing teeth, and talking, the asymmetry becomes more apparent. Usually, the activity that most concerns the patient is smiling. When smiling, the amount of asymmetry is variable from person to person and from one time to another depending whether or not the individual exposes their lower teeth during smiling (Fig. 1). This tooth exposure requires the contraction of the DLI. Although the severity of the deformity is variable, even slight asymmetries are noticeable to the patient. Occasionally, facial asymmetry when expressing other emotions, such as anger or sorrow, is also a concern. Problems with speech and with eating and drinking are not commonly significant factors in patients seeking correction.

Since 1994, 42 adult patients have undergone DLI resection. The anatomy of the muscle, the operative technique, and the effectiveness of the procedure are outlined. Thirty-six patients were available for a telephone survey.

**Anatomy**

The orbicularis oris, DLI, DAO, mentalis, and platysma influence the position of the lower lip. The levators of the upper lip have an indirect influence on the lower lip position by elevating the commissure of the mouth. The DLI, previously known as the quadratus labii inferioris, is the muscle most responsible for depression of the lower lip in facial animation.\(^4\) It takes origin from the lower lateral surface of the body of the mandible, inferior to the mental foramen. At its origin, the most lateral 1-2 cm of the DLI is covered by the origin of the DAO. From its origin, which is up to 3 cm wide, the muscle fibers of the DLI are directed cephalad and medial, covering the mental nerve, which lies on the deep surface of the middle part of the muscle. The fibers insert into and inter-digitate with the inferior and superficial surface of the orbicularis oris. Thus, there are fibro-muscular attachments to the skin and vermilion of the lower lip (Fig. 2).

The insertion into the central part of each

![Figure 1](image-url) Patient with partial right facial paralysis who, when smiling, shows her left lower teeth due to the unopposed action of the intact left DLI.
hemi-lip is approximately 2 cm wide. The action of the DLI is to roll the vermillion outwards (evert), depress the lower lip, and move it laterally. As the DLI is the most active lower lip muscle during common facial expressions, paralysis of this muscle produces the main deformity in MMN paralysis.

The DAO, (also known as the triangularis), takes origin from the mandible laterally and inferiorly to the DLI. Thus, part of the DAO lies superficial to the origin of the DLI. From its origin, the DAO curves upward in a triangular fashion to insert into the modiolus (Fig. 2). It has fibrous attachments to the upper half of the labiomental fold. Its action is to depress the corner of the mouth and deepen the labiomental fold, and along with the DLI acts in the expression of sorrow and anger.

The platysma muscle has a wide origin from the fascia over the pectoralis major and deltoid, inserting into the mandible, the skin just above the mandible, and the superficial fascia (sub muscular aponeurotic system) of the cheek, blending with the muscles of the lower lip. With contraction, its main effect is to tighten the skin of the neck; however, through its facial connections it has a minor role in depressing the lip.6 The mentalis, which is frequently included with the lower lip depressors, is in fact a weak elevator of the lip. The muscle arises from the anterior mandible at the midline and at the level of and below the incisor roots. The muscle fibers pass downward to insert into the skin of the chin. Contraction of the mentalis forces the chin skin against the mandible, dimpling the skin and closing the lower buccal sulcus.1

Methods

Patient selection

Not all patients with facial nerve paralysis or MMN palsy require DLI resection. A careful examination of the patients’ controlled and spontaneous smile and laugh is required. If the smile or laugh involves depression of the lower lip, resulting in exposure of the lower teeth, then the asymmetry will be marked and DLI resection may be indicated.

If it is felt that the patient may benefit from a DLI resection, a muscle block with local anaesthesia is usually done. The muscle is easily anaesthetised by the percutaneous injection of local anaesthetic into the muscle belly (Fig. 3(A) and (B)). By producing DLI paralysis, the affect of surgically resecting the DLI will be simulated. Both surgeon and patient can evaluate the appearance of the lip with different expressions. This will allow the surgeon to confirm the extent that the lower lip asymmetry can be corrected by muscle resection and will allow the patient to appreciate the effect of surgical resection.

The location of the DLI is variable from person to person. Its position can easily be demonstrated by asking the patient to show their lower teeth. The examiner palpates along the vermillion border of the lower lip, gently pushing the lip upwards. The central and the lateral part of the lip were easily pushed upwards by the examiner’s finger. However, between the medial and lateral 1/3 of the lip, resistance to upward and medial movement is encountered. The location and the width of the muscle belly of the DLI can be determined by the location of the resistance. Sometimes the muscle belly can be palpated as it passes obliquely into the lip. The position of the DLI muscle is marked on the skin and 0.5-1 ml of local anaesthetic is injected into the mid-portion of the muscle along the lateral border. The cephalic part of the muscle should not be injected to avoid inadvertently blocking the orbicularis oris muscle.

Following the anaesthetic block, if the patient is still undecided about the effectiveness of depressor ablation they may wish to experience the paralysis for a longer period of time. This can be achieved by a botulinum toxin (Botox®) injection into the muscle (Fig. 4(A) and (B)). If the patient wishes to avoid surgery and is willing to come back for repeated injections this is an alternative to surgical removal of the muscle. Two and a half units of Botox are injected into three to five separate locations along the length of the DLI.
Operative technique

DLI resection can be performed under local infiltration and mental nerve block or under general anaesthesia when combined with other facial paralysis procedures. The position of the muscle is marked out preoperatively on the skin of the lower lip. The muscle is exposed through a mucosal incision lateral to the midline 0.5 cm above the buccal sulcus. The dissection passes inferior to the inferior fibers of the orbicularis oris, which must be retracted cephalad. The branches of the mental nerve and its main trunk are identified, and these are gently retracted medially or laterally to expose the DLI muscle. The muscle is identified by the direction of the muscle fibers, which are oblique to the orbicularis oris. The muscle, although usually a discrete band, may be difficult to delineate due to fatty tissue. A segment of the muscle belly should be resected across the full width of the central part of the muscle belly. It is important to define the lateral border of the muscle to ensure that it is completely resected. Simple muscle transection will probably allow reconnection of the muscle fibers and continued function.

Figure 3  (A) A patient with isolated left marginal mandibular paralysis showing asymmetry of the lower lip when smiling. (B) Following an injection of local anaesthetic into the muscle belly of the depressor labii inferioris. The lower lip is now symmetrical.

Figure 4  (A) Patient with isolated left mandibular nerve paralysis. (B) Following botulinum toxin (Botox®) injection into the depressor labii inferioris, as shown with marking pen.

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Demographics

A retrospective chart review revealed that between July 1994 and August 2003, 42 adult patients were treated for MMN palsy with DLI resection by the senior author (RTM). These consisted of 31 females and 11 males, with ages ranging from 20 to 67 years. The average age was 40 years old. The aetiology of the paralyses is shown in Graph 1; the most common causes being acoustic neuroma and congenital cases.

Seven cases had only the MMN involved, whereas 35 cases had unilateral facial nerve paralysis. The seven cases of isolated MMN palsy consisted of three congenital cases, two cases following facial surgery, one paralysis from facial trauma, and one CVA. The right side was involved in 24 patients, while the left was involved in 18 patients.

None of the 42 cases had any previous lower lip rebalancing or reanimating procedures, however, 14 patients had undergone previous facial paralysis procedures (cross facial nerve grafting, gracilis microneurovascular transfer, or static sling to the mouth). The DLI resection was performed in combination with other facial paralysis procedures on 31 occasions and was performed alone 11 times.

The indication for DLI resection was a significantly asymmetrical lower lip when smiling, which was of concern to the patient.

Survey

Thirty-six of the 42 patients could be contacted for a telephone survey (86% response rate). The follow-up period ranged from 2 months to 7 years.

The survey respondents were asked about the symmetry of their lower lip at rest and with smiling and how this had been affected by the procedure. The survey questioned if the lack of symmetry of the lower lip when expressing emotions of anger, sorrow, or disgust was a concern either before or after the DLI resection. They were asked if there were changes to speech, lip biting, lip numbness, or oral continence following the DLI resection.

Statistical analysis

Two tailed paired sample $t$-tests were performed to evaluate the significance of changes to lower lip symmetry at rest and with smiling. Changes to oral continence and lip biting were also analysed. Result was statistically significant if $P$ was less than 0.05.

Results

Of the 42 DLI resections performed, 35 cases were assessed as successful by the surgeon and patient at the time of the postoperative evaluation (Fig. 5(A) and (B)). Seven patients failed to achieve the expected results, as there was still significant DLI function causing asymmetry with smiling. Five of these patients had repeat DLI resections and three achieved the desired result with a second resection, whereas one patient achieved the desired results with a third resection. Following three attempts at a DLI resection, one patient continued to have DLI action with smiling and subsequently had a botulinum toxin injection into the DLI with good results. Two patients chose not to have a repeat DLI resection. Thus, the surgeon considered that the DLI effect on the lower lip had been removed in 39/42 cases (93%). There were no complications of bleeding, haematoma, infection, or postoperative pain.

Survey results

Rest position

The 36 survey respondents were asked how the DLI resection had affected the symmetry of their lower lip at rest. Of the 36 respondents, 13 patients felt their lower lip was symmetrical prior to the DLI resection and remained symmetrical following the procedure (no change). Two patients reported that their lower lip was symmetrical prior to the procedure but had shown some asymmetry following the procedure (worse).

Twenty-one patients reported having asymmetrical lower lips at rest prior to surgery. Of these 21 patients, 18 patients were improved following the procedure ($P = 0.0001$), three patients continued to have an asymmetrical lower lip at rest.
Smiling
Changes to lower lip symmetry with smiling are shown in Graph 2. Following the DLI resection, 29 patients (81%) reported that their lower lip was more symmetrical when they smiled and seven felt that they were unchanged. Of these 29 patients, 13 felt that their lower lip was completely symmetrical and 16 patients felt their lower lip had improved from significantly asymmetrical to slightly asymmetrical. This improvement was statistically significant with \( P < 0.0001 \). No patients stated that their lower lips were less symmetrical with smiling.

Other emotions
Patients were asked if, prior to their DLI resection, the lower lip asymmetry concerned them when expressing emotions such as anger and sorrow. Nineteen patients (53%) stated that this was a concern to them (Graph 3).

They were then asked if, following their DLI resection, the resulting lack of movement in the lower lip concerned them when expressing emotions such as anger and sorrow. Twenty-seven respondents stated that the fact that their lower lip did not move when they expressed these emotions was of no concern. Of the 14 patients, who had stated that the asymmetry was a major concern prior to the DLI resection, only two patients subsequently stated that the lack of lower lip movement after DLI resection was of major concern and six patients said it was only a minor concern (\( P < 0.0001 \)) (Graph 3).

Speech
No patient reported any deterioration in speech, 27 stated their speech was unchanged, seven patients stated that their speech improved following DLI resection, and two patients did not answer this question.

Oral continence
Changes to oral continence are assessed as either drooling saliva or drooling during meals. Eighteen patients drooled in some way prior to the DLI resection. Following DLI resection, nine patients

Figure 5  (A) Patient with left total facial paralysis showing asymmetry of the lower lip due to contraction of the right DLI. (B) Following a muscle transfer to the left cheek for smile reconstruction accompanied by a right DLI resection.
stated that the severity of their drooling symptoms improved and 22 patients were unchanged. Five patients who did not drool before the resection stated that they occasionally drooled after the operation; three of these patients had unilateral facial paralyses and two had isolated MMN palsy. The changes to oral continence, either improved or worse, were not statistically significant, \( P = 0.147 \).

**Sensation**

Twenty-seven patients reported no change in lower lip sensation following the procedure and five patients reported some initial altered sensation that subsequently improved. Four patients reported an altered sensation that did not improve.

**Lip biting**

Of the 20 patients, who rarely bite their lip prior to their DLI resection, one occasionally bites their lip now. Of the 16 of the patients who had problems with lip biting preoperatively, 10 patients were improved and six patients remained the same following their DLI resection. This improvement in lip biting was statistically significant \( P = 0.007 \).

**Oral hygiene**

No patients reported difficulty with tooth brushing or oral hygiene as a result of their DLI resection.  

**Isolated DLI resections**. There were 11 cases where DLI resection was the only procedure performed. These 11 cases consisted of seven patients with isolated MMN palsies and four unilateral (two complete, two incomplete) patients who had no previous lower lip procedure. Two patients could not be contacted for follow up. Of the nine patients who were contacted, seven reported an improvement in their smile symmetry while the remaining two stated their smile was unchanged. Speech was either improved (one person) or unchanged (eight people). Drooling symptoms were unchanged in six cases while three patients said that they now drooled occasionally where they never drooled before.

**Discussion**

Many techniques have been advocated for the treatment of the marginal mandibular lip deformity. These involve procedures either on the paralysed lip to attempt to reanimate it or on the nonparalysed lip to achieve symmetry. Procedures directed at the paralysed lip include cross facial nerve grafts and digastric and platysma muscle transfers. Edgerton\(^7\) first described transfer of the anterior belly of the digastric muscle. This involved dividing the mandibular insertion of the muscle and attaching it to the lower lip with a fascia lata graft. Conley\(^8\) left the muscle insertion intact but divided the intermediate tendon and tunneled it up to the lateral lower lip where it was anchored. Because the mandibular division of the trigeminal nerve innervates the anterior belly of the digastric muscle, the patient must undergo re-education to use the transfer appropriately. Frequently, the muscle tends to act more as a passive restraint on the lower lip rather than an active depressor.

Terzis\(^9\) has further modified the digastric transfer into a two-stage procedure. The first stage consists of co-aptng a nerve graft to a MMN branch on the nonparalysed side. At the second stage the digastric muscle is transferred, the motor nerve to the digastric is divided, and then co-apted to the previously placed nerve graft. Although movement was not demonstrated this procedure could provide spontaneous activation of the digastric through innervation from the normal side. In cases of isolated MMN palsy, where the cervical division of the facial nerve is functioning, Terzis\(^9\) has also described the use of the platysma muscle transfer. This involves dissecting the entire platysma muscle from mandible to clavicle, identifying the vascular and nerve pedicles, and then harvesting the lateral two thirds of the muscle, which is then tunnelled to the lower lip. In her follow-up study excursion of the transferred muscle was not apparent.\(^6\) A disadvantage of these procedures is their complexity and duration, often requiring a full day of surgery. Another procedure, the effectiveness of which has not been published, is a hypoglossal nerve transfer to provide a dynamic reconstruction of the paralysed lower lip.\(^10\) In contrast to these procedures DLI resection can be performed as an outpatient procedure under local anaesthetic and patients are left with no visible scars or contour deformities.
Puckett\textsuperscript{11} described excising a wedge of lower lip from the nonparalysed side and suspending the nonparalysed orbicularis muscle through a nasolabial incision. Glenn\textsuperscript{12} recommended a full thickness wedge excision of the paralysed lower lip followed by a vermilion border advancement to correct the vermilion inversion deformity. Both of these procedures may result in facial scars, notching of the lower lip, and long-term failure due to continued muscle imbalance.

Another possible approach to weakening the normal side is transection of the MMN. This may fail because branches of the nerve are easily missed. In addition, the MMN partially innervates the lower lip orbicularis oris and its transection may lead to bilateral weakness of the orbicularis oris and problems with oral incontinence.

As none of these surgical techniques have proven adequate for the correction of lower lip asymmetry, we looked for another solution. It was our hypothesis that patients with a unilateral paralysis of the MMN are concerned primarily about the asymmetrical appearance of their lower lip rather than the lack of movement per se. This concern is present particularly when smiling; however, it is also present when showing emotions of anger, sorrow, or disgust and in some patients when at rest. As a result, our approach to this problem is to try to achieve symmetry by selective myectomy of the DLI on the nonparalysed side. Since the DLI is responsible for lower lip depression during smiling and speech, it is the only muscle that needs to be ablated. Curtin\textsuperscript{13} was the first to suggest myectomy of the depressor muscles on the nonparalysed side in 1960 and Rubin\textsuperscript{14} later suggested resection of the DLI. Details of the procedure were not provided and the effectiveness of the procedure was not reported.

Once the anatomy of the DLI is understood, its resection can be performed safely and effectively. The mental nerve branches must be identified, preserved, and gently retracted. A clear blood free exposure of the muscle belly, particularly the lateral margin, is necessary. At least 1 cm of muscle should be resected through the full width of the muscle belly. If insufficient muscle is resected, or the lateral margin left intact, the procedure may need to be repeated. Despite our review of the anatomy through cadaver dissections 14% of surgeries did not remove the DLI function at the first attempt pointing out that there can be difficulty in defining the muscle belly. In addition in spite of our care in handling the mental nerve branches 11% of patients had permanently altered lower lip sensation.

In our series of patients, 29 out of 36 reported an improvement in the symmetry of their smile, 11 of these patients reported that their smile changed from significantly asymmetrical to completely symmetrical. Thus, the primary goal of the procedure was met in 80% of patients. This finding was lower than that reported by the treating physician who reported 93% of patients had a successful DLI removal. This discrepancy may be the result of patient expectations of the procedure. When the patient is asked whether their lower lip appears symmetrical following surgery, the patient may evaluate commissure droop, red lip fullness, or lip contour, none of which are corrected with a DLI resection. Therefore, 80% of patients reported an improvement in symmetry whereas 93% of patients were evaluated as having no DLI activity following surgery. Both of which demonstrate success of the procedure.

Prior to DLI resection, 19 out of 36 patients were also upset by the lack of symmetry when expressing emotions other than smiling, such as anger or sorrow. After DLI resection, 16 of these 19 patients felt that their appearance was improved when expressing these emotions. For the majority of patients, achieving symmetry of their lower lip when expressing emotions such as anger or sorrow appears to be of more concern than the lack of movement in the lower lip.

It has been suggested that having the depressor muscle resected may result in speech deficits (Edgerton, 1966). In our series, 27 out of 36 patients stated that their speech was unaffected by DLI resection. Interestingly, seven patients stated that their speech was improved. No patient reported deterioration in speech. Why speech was improved in over one quarter of patients is unclear. Perhaps, having a more level lower lip enables better contact when producing bilabial sounds such as 'B' and 'P'. Similarly, a more level lower lip may also explain why nine out of 36 patients reported an improvement in drooling and dribbling. The nonparalysed orbicularis oris maintains tone in the lower lip and provides oral closure. Five patients stated that they now occasionally drooled whereas they never drooled before DLI resection. It is not clear why oral continence should have deteriorated in these patients because the orbicularis oris of the nonparalysed side is still functional and it is the major muscle for the maintenance of oral continence.

For patients with MMN paralysis a symmetrical lower lip when smiling appears to be their primary goal. DLI resection is a relatively simple and effective procedure for achieving this symmetry. The expected results of surgery can be predicted by a trial of local anaesthetic or botulinum toxin to block the DLI. The surgical technique requires good
exposure to protect the mental nerve and expose the muscle belly in order to ensure complete ablation of the muscle.

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