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Hypoglossal-facial nerve anastomosis: assessment of clinical results and patient benefit for facial nerve palsy following acoustic neuroma excision

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Despite advances in neuro-otological techniques permanent complete facial palsy may still occur in up to 10% of patients undergoing removal of cerebellopontine angle tumours. Hypoglossal-facial nerve anastomosis is the procedure of choice in our unit for facial reanimation in such patients and below we report the results of hypoglossal-facial nerve anastomosis performed on 29 patients. Assessment of patient benefit from hypoglossal-facial nerve anastomosis was obtained using a questionnaire based on the Glasgow Benefit Inventory. The results showed all patients to have an improvement in their House Brackmann grade following hypoglossal-facial anastomosis with 65% achieving grade III or better. Of the 20 patients who completed the questionnaire, 18 showed a positive benefit (median score 59.5, range 40–77). There was a significant correlation ($P < 0.045$) between the Glasgow benefit inventory score and House Brackmann grade. Outcome was not affected by the time interval between the acoustic neuroma surgery and performing the hypoglossal-facial nerve anastomosis, sex or length of follow-up. However the Glasgow benefit score was significantly influenced by age ($P = 0.023$) with younger patients showing more benefit independent of improvement in facial nerve function.

Keywords *nerve anastomosis* *hypoglossal nerve* *facial nerve* *facial palsy* *acoustic neuroma* *quality of life*

Preservation of facial nerve function is an extremely important aspect of acoustic neuroma surgery. Facial palsy results in significant physical and psychological effects on the patient, especially when coupled with the frequent loss of hearing following excision of an acoustic neuroma. Therefore in those patients who have a facial palsy following excision of an acoustic neuroma it is important to provide adequate physical and psychological rehabilitation.[1]

There are various techniques which surgeons may use to treat facial nerve palsy in order to restore both form and function to the facial musculature. Ideally the rehabilitation of the paralysed face should achieve normal appearance at rest, symmetry with voluntary motion, controlled balance in expressing emotion and restoration of oral, nasal and ocular sphincter control.[2] Dynamic techniques include primary anastomosis,[3] cable grafts, crossed nerve anastomosis and neuromuscular free flaps.[4] Static techniques may be used alone or subsequent to dynamic techniques to enhance the functional and cosmetic result and include fascial slings, face lifts and brow suspension. In addition management of the eye in facial palsy may benefit from upper lid gold weight implants, upper lid springs and canthoplasties.[5]

There is no doubt that the quality of life is adversely affected in patients who have a facial palsy. In order to assess the success of a surgical procedure it is important to ascertain the level of patient benefit from the procedure as well as the improvement in clinical signs and symptoms. The Glasgow benefit inventory is a validated measure of patient benefit from otorhinolaryngological operative procedures that has been shown to reflect positive and negative

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benefit.[6] We have used this to determine the change in quality of life in patients who undergo hypoglossal-facial nerve anastomosis for facial palsy due to acoustic neuroma surgery.

Since the first description of hypoglossal-facial anastomosis in 1901 by Korte in Berlin,[7] there have been several reports of this technique with varying results. It is an uncomplicated, useful technique which is important for the otolaryngologist to be familiar with. However there can be additional morbidity following hypoglossal-facial anastomosis due to hypoglossal dysfunction and below we assess the problems encountered by patients undergoing the procedure in our unit.

Patients and methods

PATIENTS

Twenty-nine patients who underwent hypoglossal-facial nerve anastomosis constituted the study population. All the patients had undergone surgery for excision of an acoustic neuroma and had suffered a complete facial nerve palsy as a consequence of this procedure. Both the acoustic neuroma surgery and hypoglossal-facial anastomosis were performed by the same otolaryngologist and neurosurgeon.

Assessment of the patients was subjective. The patients facial nerve function was assessed using the House-Brackmann grading system.[8] The patients were asked specific questions with regards to problems with swallowing, food spillage, clearance of buccal debris, speech and confidence in public places (shopping and eating in restaurants). All the subjects were also asked if they were pleased to have had the surgery and whether or not they would undergo it with hindsight. In addition, a questionnaire was sent to all the subjects in order to obtain a Glasgow Benefit Inventory rating. There were 18 questions in the questionnaire which were based on the Glasgow benefit inventory as described by Robinson *et al.*[6]

SURGICAL PROCEDURE

A standard parotidectomy incision was made, the facial nerve exposed at the stylomastoid foramen and divided just distal to this point. The hypoglossal nerve was exposed medial to the tendon of the digastric muscle by the loop of the lingual artery and divided. A vein sleeve was placed over either the facial or hypoglossal nerve. The proximal stump of the hypoglossal nerve was then anastomosed to the distal end of the facial nerve using 4–6 epineural sutures of 8 'O'nylon and the vein sleeve pulled to cover the anastomosis.

STATISTICAL ANALYSIS

Correlations between ordinal and interval variables were tested using Spearmann rank correlation. Correlations involving categorical variables (sex) were tested using the Mann–Whitney *U*-test. All tests were two-tailed and assumed significant if $P < 0.05$. Data analysis was performed using the SPSS statistical analysis software package.

Results

There were 11 men and 18 women in the study and the mean age was 55 years (range 17–79 years). The mean interval time between the acoustic neuroma surgery and hypoglossal-facial anastomosis was 15 months (range 3–60 months). The mean follow-up time was 42 months (range 4–96 months).

All patients had a House Brackmann grade VI prior to undergoing hypoglossal-facial anastomosis. House Brackmann grades following anastomosis were: 3/29 (10%) grade II, 16/29 (55%) grade III, 4/29 (14%) grade IV and 6/29 (21%) grade V (see Fig. 1). Figures 2 and 3 show patients following hypoglossal-facial anastomosis with a House Brackmann grade II and IV, respectively.

Seven patients (24%) admitted to having trouble with clearing buccal debris and 10 patients (30%) had occasional trouble with food spillage. Four patients (14%) felt that their speech had worsened although all of these felt that other people did not have a problem understanding their speech. Five patients (17%) felt embarrassed to eat in public places although none of the patients felt embarrassed to go

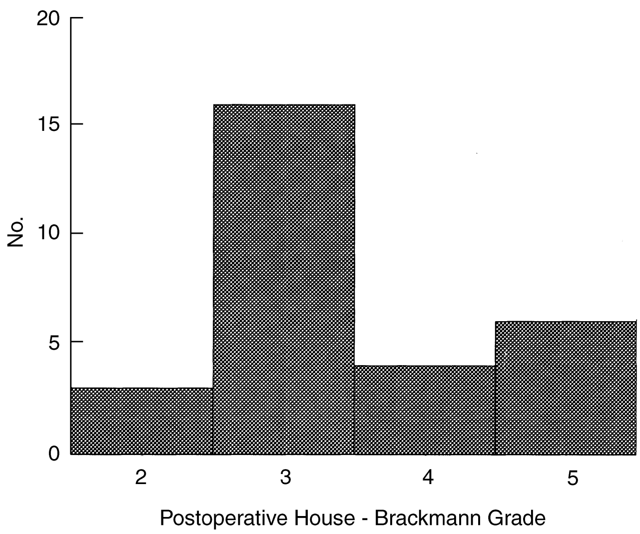

Figure 1. Histogram of postoperative facial nerve House Brackmann grade.

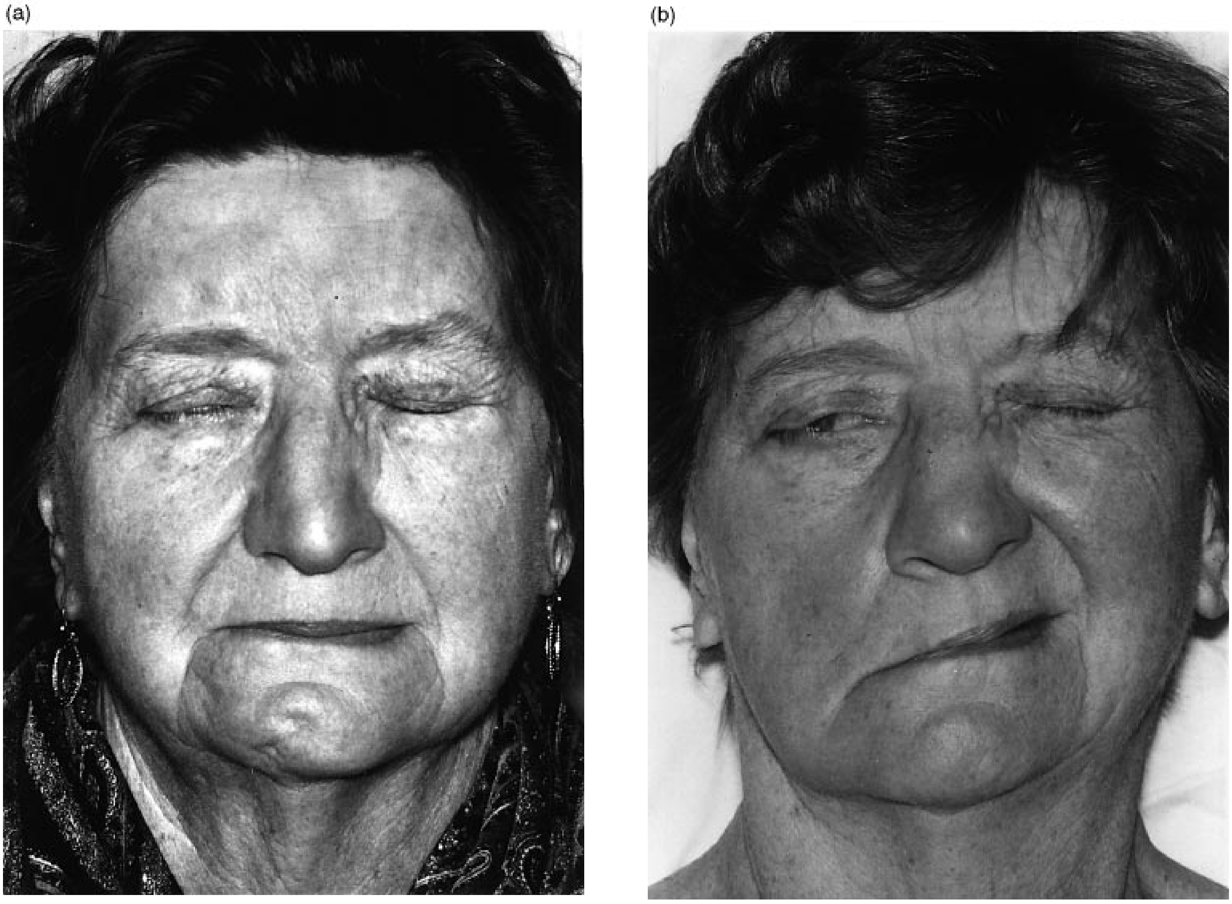

Figure 2. Pre- and postoperative photograph of a patient with a House Brackmann grade II result following hypoglossal-facial anastomosis.

shopping. All of the patients felt with hindsight that they would undergo the procedure again and would recommend hypoglossal-facial nerve anastomosis to other appropriate patients.

Twenty patients completed the Glasgow benefit inventory questionnaire. In scoring the questionnaire the responses to all 18 questions were added up with each question carrying a maximum of 5 points. The score therefore ranged from a minimum of zero (maximal negative benefit) to 90 (maximal benefit). The median score was 59.5 (range 40–77) with only one patient scoring a negative benefit of 40 and one patient scoring a 'neutral benefit' of 45 (see Fig. 4).

There was a significant correlation between the Glasgow benefit inventory score and House Brackmann grade improvement ($r = 0.452$; $P = 0.045$). There was a significant negative correlation between the age of the patient and the Glasgow benefit inventory score ($r = -0.0506$, $P = 0.023$) suggesting that the benefit of the operation as perceived by the patient is greater in younger patients. This is despite the fact that no correlation was found between the patient age and House Brackmann grade improvement in the same group of patients ($r = 0.015$, $P = 0.950$).

The length of interval between the acoustic neuroma resection and hypoglossal-facial anastomosis did not effect either the resultant House Brackmann grade ($r = 0.04$; $P = 0.838$) or the Glasgow benefit inventory score ($r = 0.018$; $P = 0.939$). No significant associations were found between sex, length of follow up and either the Glasgow benefit inventory score or improvement in the House Brackmann grade.

Discussion

The incidence of facial nerve palsy following acoustic neuroma surgery is low, with anatomical facial nerve preservation rates of > 90% reported.[9,10] In our unit we have preserved facial nerve function in 62/68 (91.2%) and retrosigmoid acoustic neuroma resections in 115/127 (90.5%) of

(a) (b)

Figure 3. Pre- and postoperative photograph of a patient with a House Brackmann grade IV result following hypoglossal-facial anastomosis.

translabyrinthine acoustic neuroma resections. Patients with a preoperative facial weakness have a poor prognosis in terms of facial nerve function following acoustic neuroma surgery.[11,12] This may be due to infiltration of the facial nerve by the acoustic neuroma, especially if the tumour is large.[12,13] Facial nerve palsy following acoustic neuroma surgery occurs more often with larger tumour resections.[11,14] In our unit we preserved facial nerve function in 108/109 (99%) small (< 2.5 cm) acoustic neuroma resections compared with 53/63 (84%) medium sized tumours (2.5–4 cm) and 17/23 (74%) large tumours (> 4 cm).

Intra-operative neurophysiological facial nerve monitoring may contribute to the preservation of facial nerve function by helping the surgeon to identify and confirm that the facial nerve is intact, especially when operating on larger tumours.[15,16] However, there is no objective evidence that the use of facial nerve monitoring leads to improved facial nerve preservation during acoustic neuroma surgery.[17] In our centre we had a facial nerve preservation rate following acoustic neuroma excision of 84.5% (95/112) prior to using facial nerve monitoring which has improved to 98.8% (84/85) since the use of a facial nerve monitor intraoperatively. However these figures may also reflect a surgical learning curve as seen in other series.[18]

Primary anastomosis is the preferred procedure for surgical reconstruction of the facial nerve as it has the advantage of not requiring sacrifice of a normal nerve as is the case with donor techniques. Hypoglossal-facial nerve anastomosis has been advocated for patients with loss of the proximal trunk of the facial nerve who are not candidates for primary end-to-end anastomosis, an intracranial nerve interposition graft or an intracranial-intratemporal nerve interposition graft. Reanimation using the contralateral facial nerve has also been advocated as it has the advantages of not sacrificing other cranial nerves as well as a possibility of recovery of emotional expression.[19] However, compared to hypoglossal-facial anastomosis, it is a technically more difficult procedure with a less powerful, more delayed reinnervation and additional support by muscle transfer is recommended.[9]

The published results of hypoglossal-facial anastomosis vary from series to series but in general satisfactory to good results can be expected. Our results of clinical improvement

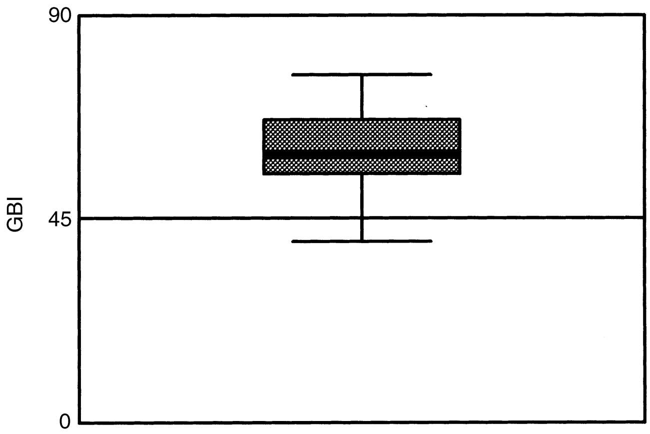

Figure 4. Box and whisper plot of Glasgow benefit inventory results following hypoglossal-facial anastomosis. The gridline at Glasgow Benefit Inventory (GBI) = 45 indicates a score representing no benefit. The box represents the interquartile range with the median within; the whiskers represent the 2.5th and 97.5th centiles.

to House Brackmann grades III or better in 65% of patients are slightly lower than some of the other reported series including Samii and Mathhies[20] who found 55 (74%) out of 74 cases of hypoglossal-facial anastomosis to be better than House Brackmann grade III, Kukwa *et al.*[21] with 18 (78%) out of 23 to be better than House Brackmann grade III and Darrouzet *et al.*[22] who found 23 out of 26 (88%) to be grade III or better. However there are other reports of poorer results such as Linnet and Madsen[23] who found only eight (25%) out of 32 patients to have achieved grade III or better. Comparison with earlier series is a bit more difficult as results were often categorized as 'excellent', 'good', 'fair' or 'poor' but in general most authors report at least a 'fair' or 'moderate' result in the majority of patients. Details of the results of other series are given in Table 1.

The ideal time to perform hypoglossal-facial anastomosis remains controversial. It is clear, however, that when spontaneous recovery of facial function does occur it tends to be within 6–12 months and is superior to surgical reanimation procedures.[24,25] There are reports of good results of hypoglossal-facial anastomosis being performed within a few weeks of acoustic neuroma surgery.[1,26] It has been suggested that an interval of > 6 months to 1 year may adversely affect the outcome of hypoglossal-facial anastomosis due to atrophy and subsequent fibrosis of the facial nerve and mimetic muscles.[23,27] Conversely there are reports of reinnervation following hypoglossal-facial anastomosis as late as 2–3 years after onset of facial palsy.[21,28] At present we tend to wait for a period of 1 year following acoustic neuroma surgery. However the results of this study show no correlation between the interval and outcome and therefore the time at which hypoglossal-facial nerve anastomosis is performed is probably not of importance in determining the outcome.

The age of the patient has been suggested to be a significant factor with worse results reported in the elderly,[27,29] possibly due to the more rapid progression of muscular

Table 1. Results of Hypoglossal-facial nerve anastomosis

Author	No. of patients	Results
McKenzie and Alexander (1950)[26]	33	> 75% 'excellent' restoration of facial symmetry
Conley and Baker (1979)[2]	137	89 'good facial movement'; 130 'good resting tone'
Gavron and Clemis (1984)[27]	30	12 'excellent'; 10 'good'; 6 'fair'; 2 'failure'
Chang and Shen (1984)[27]	12	10 'good'; 2 'fair'
Pensak *et al.* (1986)[1]	61	26 'excellent/good'; 29 'fair'; 6 'poor'
Brudny *et al.* (1988)[32]	30	10 'mild dysfunction'; 17 'moderate dysfunction'; 3 'minimal benefit'
Sabin *et al.* (1990)[29]	121	52 'minimal weakness'; 58 'moderate weakness'; 11 'severe weakness'
Kunihiro *et al.* (1991)[34]	27	25 'serviceable facial function obtained'
Pitty and Tator (1992)[35]	22	14 'good', 3 'fair', 4 'poor', 1 'failure'
Samii and Matthies(1994)[20]	74	12 HB II ; 43 HB III; 17 HB IV; 2 HB V
Kukwa *et al.* (1994)[21]	23	8 HB II; 10 HB III; 5 HB IV
Linnet and Madsen (1995)[23]	32	8 HB III; 10 HB IV; 10 HB V; 4 HB VI
Arai *et al.* (1995)[37]	8	All HB III
Kunihiro *et al.* (1996)[44]	29	7 HB III; 18 HB IV; 1 HB V
Saeed and Ramsden (1996)[45]	8	6 HB IV; 1 HB V; 1 HB VI
Samii and Matthies(1997)[9]	24	5 HB II; 18 HB III; 1 HB IV
Darrouzet *et al.* (1997)[22]	26	5 HB II; 18 HB III; 1 HB IV
Laskawi (1997)[46]	10	6 HB III; 4 HB IV

HB = House Brackmann facial nerve grading.

atrophy and subsequent fibrosis in this group of patients.[20] In our series there was no correlation between age and House Brackmann grading following hypoglossal-facial anastomosis. However the results show that the Glasgow benefit inventory scores are better in younger patients. Therefore it seems that the younger the patient the better the perceived benefit with no correlation to the improvement in House Brackmann grading.

Recovery of facial function following hypoglossal-facial anastomosis typically begins at about 4–6 months and may take up to 18 months or longer.[2,27,29] Neuromuscular retraining of the facial muscles is an important aspect of rehabilitation following hypoglossal-facial anastomosis to aid recovery of facial function.[30,31] The use of electromyographic rehabilitation following hypoglossal-facial anastomosis may benefit recovery of facial movement in these patients.[32,33]

Side-effects of hypoglossal-facial anastomosis include: tongue atrophy with possible difficulty in speech, mastication and swallowing; hypertonicity with resulting overproduction of facial movements during eating, talking and swallowing; and mass movements of the face which prevents complete voluntary control over emotional expression.[2,27,34] There may also be problems with oral hygiene and food debris because of limited oral-buccal function and tongue paralysis. Therefore, factors which may preclude hypoglossal-facial anastomosis include: glossopharyngeal, vagus and contralateral hypoglossal nerve palsies; dysphagia of any aetiology; and neurofibromatosis type 2 as these conditions combined with hypoglossal dysfunction may result in significant swallowing difficulties. The return of function of the frontalis muscle is often reported as poor and this is thought to be due to the fact that there is a relatively small number of fibres passing to the frontalis branch from the trunk of the postgeniculate portion of the facial nerve.[35]

In our series, although seven (24%) patients had trouble with clearing buccal debris and 10 (30%) had trouble with occasional spillage of food during mastication, none of these patients had a negative Glasgow benefit inventory rating. In addition only five (17%) patients felt embarrassed to eat in public places. The potential problems with articulation following hypoglossal-facial anastomosis may be significant in patients whose occupation demands fluent speech,[34] but this was not the case in our study. Only four (14%) patients had noticed a slight deterioration in speech following hypoglossal-facial anastomosis and none felt disabled or embarrassed by their quality of speech. Thus it would appear that although there can be problems due to hypoglossal dysfunction following hypoglossal-facial anastomosis these are largely outweighed by the improvement (even a modest improvement) in facial nerve function leading to an overall positive benefit for the patient.

In order to minimise hypoglossal dysfunction some surgeons advocate utilizing modified techniques of the classic hypoglossal-facial anastomosis which include hypoglossal-facial interposition jump grafting[36] and hemihypoglossal-facial nerve anastomosis.[37–39] Although the hypoglossal nerve is not a polyfascicular nerve it is relatively thick and one-half of the nerve is adequate for anastomosis with the facial nerve.[40] Supplementary innervation of the tongue muscles by the cervical ansa has also been described[21] although anastomosis of the descendens hypoglossi with the hypoglossal nerve has not been shown to prevent hemiatrophy of the tongue following sectioning of the hypoglossal nerve.[41] Combination of hypoglossal-facial anastomosis with simultaneous myoplasty such as temporalis or masseter muscle transposition has also been advocated to improve ocular protection although this does mean that the patient has to undertake more intensive rehabilitation in order to obtain optimal results.[21,42,43]

Although other nerves, including the spinal accessory, phrenic and glossopharyngeal nerves, have been used to reanimate the paralysed face, surgery of the hypoglossal nerve and facial nerve produces the best results. This is thought to be due to the close connections of the facial and hypoglossal representations at motor cortex and brain stem levels and is reflected by the association of face and tongue movements in healthy individuals.[9,35] Use of the spinal accessory nerve has significant disadvantages which include shoulder drop, inability to elevate the shoulder and pain.[23,26]

Currently in evaluating results of a surgical procedure it is important to assess the patient benefit in addition to the improvement seen by the surgeon through clinical examination. The Glasgow Benefit Inventory is a useful way of assessing patient benefit and in our series showed that patients with a facial palsy do have a positive benefit from hypoglossal-facial anastomosis. In addition the fact that the improvement in the Glasgow benefit inventory was related to the improvement in the House Brackmann grade shows that the House Brackmann grade is a useful indicator of the outcome of hypoglossal-facial anastomosis. Therefore the House Brackmann facial nerve grading system is a useful method for assessment of facial reanimation procedures as many otolaryngologists are familiar with it and our study shows it to correlate well with the improvement in the quality of life in these patients.

The results from our series show an improvement in facial nerve function in all the patients who underwent hypoglossal-facial nerve anastomosis for facial palsy due to acoustic neuroma surgery. The best time to perform this procedure remains unclear and in our study was not an important factor in determining outcome. A significant minority of patients had problems with the loss of hypoglossal nerve function following hypoglossal-facial anastomosis. However, all of the patients would be willing to undergo the procedure again and the majority had a positive benefit from the procedure as illustrated by the Glasgow benefit inventory scores in this study. It also appears that the improvement in quality of life following hypoglossal-facial anastomosis is greater in younger patients. Hypoglossal-facial nerve anastomosis remains a useful procedure for facial reanimation and can produce good clinical results as well as leading to an improvement in the quality of life in patients with a facial palsy.

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