Nonsurgical Treatment for Posttraumatic Complete Facial Nerve Paralysis

Alok Thakar, MS, FRCSed; Madan P. Gupta, MS; Achal Srivastava, DM; Deepak Agrawal, MCh; Atin Kumar, MD

IMPORTANCE Current recommendations envisage early surgical exploration for complete facial nerve paralysis associated with temporal bone fracture and unfavorable electrophysiologic features (response to electroneuronography, <5%). However, the evidence base for such a practice is weak, with the potential for spontaneous improvement being unknown, and the expected results from alternative nonsurgical treatment also undefined.

OBJECTIVE To document the results of nonsurgical treatment for posttraumatic complete facial paralysis with undisplaced temporal bone fracture and unfavorable electrophysiologic features.

DESIGN, SETTING, AND PARTICIPANTS Prospective cohort study recruiting from April 2010 to April 2013 at a tertiary care university hospital. Follow-up continued until 9 months or until complete recovery if earlier. Study group included 28 patients with head injury–associated complete unilateral facial nerve paralysis with unfavorable results of electroneuronography (<5% response) with or without undisplaced temporal bone fracture. Undisplaced temporal bone fractures were documented in 26 patients (24 longitudinal fractures and 2 transverse fractures).

INTERVENTIONS Patients received prednisolone, 1 mg/kg, for 3 weeks combined with clinical monitoring every 2 weeks and electromyography monitoring every 4 weeks. As per study protocol, surgical exploration was limited to patients demonstrating motor end plate degeneration on results of electromyography, or having no improvement until 18 weeks.

MAIN OUTCOMES AND MEASURES Facial nerve function was evaluated by the House-Brackmann grading system; Forehead, Eye, Mouth, and Associated defect grading system; and the modified Adours system. Observations were completed at 40 weeks.

RESULTS Among the 28 patients in the study (3 women and 25 men; mean [SD] age, 32.2 [8.7] years), facial nerve recovery with conservative treatment alone was noted in all patients. No recovery was seen in any patient at the initial 4-week review. The first signs of clinical recovery were noted in 4 patients by 8 weeks, in 27 patients by 12 weeks, and in all patients by 20 weeks. No patient required surgical exploration. At 40 weeks, 27 patients recovered to House-Brackmann grade I/II and 1 patient to grade III. All 24 patients with longitudinal fractures had grade I/II recovery.

CONCLUSIONS AND RELEVANCE For undisplaced temporal bone fractures, nonsurgical treatment leads to near-universal recovery to House-Brackmann grade I/II and is superior to reported surgical results. Recovery is delayed and usually first manifests at 8 to 12 weeks after the fracture. In the current era of high-resolution computed tomography, surgical exploration should not be first-line treatment for undisplaced longitudinal temporal bone fractures associated with complete facial nerve paralysis and unfavorable electrophysiologic features.
he recommended treatment for posttraumatic complete facial nerve paralysis has generally been surgical.1-4 Contemporary standard textbooks of otolaryngology make similar recommendations, with decision making further calibrated by the use of electroneuronography (ENoG) and radiology.5,6 Incomplete paralysis is usually treated conservatively, as the residual activity in the nerve indicates that a fair proportion of nerve fibers are functional. Initial nonsurgical treatment has also been proposed for patients with delayed-onset paralysis,4 but identification of the onset of paralysis as immediate or delayed is often undeterminable. For complete paralysis, it is generally recommended that the integrity of nerve fibers be assessed by ENoG, and patients with unfavorable response to ENoG be recommended surgical exploration.5-10 While patients with lesser degrees of ENoG dysfunction be managed with medical measures. Criteria for unfavorable response to ENoG used by different investigators as an indication for facial nerve decompression have been electrophysiological alone (ie, 90%-95% denervation on ENoG and no response on electromyography [EMG]),8-10 or electrophysiological ENoG-EMG criteria as described above with these criteria manifesting within 7 to 21 days of the onset of paralysis.7

An alternative opinion relies less on ENoG and bases such decisions on results of radiology. Current radiology with high-resolution computed tomography (HRCT) has improved the assessment of such injuries. Per this opinion, the presence of a fracture on results of temporal bone computed tomography may be taken as a sufficient indication of significant trauma meriting surgical exploration.3,4

The natural history of such lesions without surgical treatment is, however, not clearly defined.5,6 Recovery without surgical decompression has been sporadically documented, even in situations with unfavorable response to ENoG and/or temporal bone fractures.11-13 A recent systemic review by Nash et al10 incorporating 612 patients from 35 articles included 189 patients who underwent observation with no specific treatment, 83 patients treated with corticosteroids, and 340 patients treated surgically. The 189 patients who underwent observation had better outcomes than the patients treated surgically, with 66% improving to House-Brackmann (HB) grade I, 25% achieving HB grades II to V, and 2 patients achieving an HB grade VI score. There was, however, no uniformity in the inclusion criteria among the various reports included in the review, and the authors do note a management selection bias wherein patients treated conservatively may have had less severe injuries than patients treated surgically.

The idea that surgical decompression should be undertaken immediately to be effective, although intuitive and frequently stated,1-4 is not evidence based.5,8,10,14 Other neural injuries in peripheral nerves are not necessarily explored immediately and a period of waiting for recovery is considered acceptable. An analogy may be drawn with the radial nerve which, like the facial nerve, is a predominantly motor nerve and is in relation to bone and susceptible to bony compression in trauma, and for which nerve electrical testing is undertaken by stimulating the nerve distal to the site of injury. The predominance of opinion for radial nerve injuries associated with a fracture of the humerus is against early surgical exploration.15-18 For the injured facial nerve there is also an opinion that a delay of a few weeks is unlikely to do harm, as the sprouting of the regenerating peripheral nerve axons is maximal a few weeks after injury rather than immediately.4

Other reports have noted recovery of facial function even when decompression was delayed by a few months.5,8,10,19 The rationale for our study is premised on these 2 points: that surgical exploration is not necessarily the best and only treatment for traumatic complete facial paralysis and that a delay in surgery is not necessarily harmful. It has been the experience of one of us (A.T.) that such patients have experienced spontaneous improvement while awaiting surgical decompression. This study prospectively examines a consecutive cohort of such patients to evaluate the outcomes of nonsurgical treatment for blunt head injury–related complete facial nerve palsy with unfavorable response to ENoG.

### Methods

To be eligible for recruitment to this prospective, single-arm, observational cohort study, patients had to be consenting adults with complete facial paralysis consequent to recent (<4 weeks) head injury, with less than 5% response on electroneuronography and no response on EMG (referred to as unfavorable ENoG). Patients with displaced temporal bone fractures as evidenced on results of a HRCT scan of temporal bone were excluded, but patients with undisplaced temporal bone fractures were eligible. Patients were recruited over a 36-month period from April 2010 to April 2013.

Institutional ethics committee approval was obtained from the All India Institute of Medical Sciences. Informed consent included information stating that, although there were no clear data on what treatment was best for this situation, a significant opinion advocated surgical exploration while the experience of the investigators indicated nonsurgical treatment to be also efficacious. Patients were informed that nonsurgical treatment would be undertaken with ongoing monitoring, and surgical treatment would be undertaken if at any time results
of testing indicated deterioration or if there was no improvement until 18 weeks.

Intervention and Observations
All patients received corticosteroids in conventional doses (prednisolone, 1 mg/kg, for 3 weeks with a subsequent taper to discontinuation for 10 days) along with advice for eye care and physical therapy. Clinical reviews were undertaken every 2 weeks, and electrophysiologic monitoring (EMG) for muscle denervation and degeneration was undertaken every 4 weeks. Per the study protocol, surgical exploration was to be advised only if there was EMG evidence of electrophysiologic motor end plate degeneration (fibrillation potentials) or persistent paralysis with no improvement until 18 weeks.

All patients underwent an HRCT scan of the temporal bone. 3-Dimensional volume acquisitions were undertaken and scans were evaluated in bone window settings with contiguous thin sections (thickness of 0.75-1.0 mm) in the axial and coronal planes. All HRCT scans were evaluated by a radiologist with experience in trauma and skull base radiology (A.K.). Scans were specifically evaluated for undisplaced or displaced fracture, type of fracture (longitudinal, transverse, or oblique), site of facial nerve or fallopian canal injury, and associated other complications (eg, intracranial injury or ossicular disruption).

Electrophysiologic testing was performed at initial evaluation and repeated every 4 weeks, continuing until the first signs of recovery. All electrophysiologic testing was performed at the neurology electrophysiology laboratory with a supervising neurologist (A.S.). Electroneurography (aka, evoked electromyography [EEMG]) was performed with supramaximal electrical stimulation of the facial nerve, and surface recording of the resultant compound muscle action potential at the nasalis muscle. The facial nerve main trunk was stimulated by bipolar surface stimulation at a point approximately 1 cm anteroinferior to the inferior attachment of the lobe. Initial stimulation was to the healthy side, with a current of 50 mAmp, increased incrementally by 5 to 10 mAmp in subsequent stimulations until a plateau response was noted on the compound muscle action potential amplitude. The final supramaximal stimulation current was at 120% to 125% of the compound muscle action potential amplitude. The final supramaximal stimulation current was at 120% to 125% of the compound muscle action potential amplitude. The final supramaximal stimulation current was at 120% to 125% of the compound muscle action potential amplitude. The final supramaximal stimulation current was at 120% to 125% of the compound muscle action potential amplitude. The final supramaximal stimulation current was at 120% to 125% of the compound muscle action potential amplitude.

Electromyographic recordings were performed only in patients with a complete absence of response on ENoG. The muscles tested included the frontalis, orbicularis oculi, orbicularis oris, and mentalis. Recording of spontaneous muscle activity and voluntary initiated muscle activity was undertaken by a 37-mm concentric needle inserted into the muscle. Testing included assessment of voluntary (neural initiated) muscle activity, postdenervation spontaneous muscle activity (fibrillation) suggestive of denervation and degeneration, and for polyphasic muscle activity indicative of reinnervation.

Assessment of facial nerve motor function was undertaken by the HB grading scale and the Forehead, Eye, Mouth, and Associated defect (FEMA) grading scale (eTable in the Supplement). The quality of recovery was judged by the above 2 grading systems and by the modified Adour scoring system (eTable in the Supplement). All facial nerve paralysis grading assessments were made by 2 investigators in consultation (M.P.G. and any of the other investigators). The FEMA grading system and the modified Adour system assign specific and clearly calibrated grades for each region of facial nerve motion (FEMA system: forehead, eye, mouth, and associated defect; modified Adour system: forehead, eye, mouth, and synkinesis) and minimize the subjectivity of interpretation.

Patients were followed up until at least 9 months from the last intervention (medical or surgical).

Results
A total of 35 consecutive patients meeting the inclusion criteria were initially assessed. Three patients were below the age for informed consent, 2 did not consent for recruitment, and 2 expressed an inability to undertake regular follow-up reviews. A total of 28 patients who consented for the complete protocol constituted the study group.

Demographic Profile
All 28 patients had experienced facial paralysis consequent to a road traffic accident and associated head injury. The cohort included 25 men and 3 women with ages ranging from 19 to 50 years (median, 30 years; mean [SD] 32.2 [8.7] years). A total of 26 patients had some period of alteration in sensorium after the injury: 14 experienced bleeding from the ear or nose, 1 experienced postinjury seizures, 7 had conductive hearing loss, and 1 had severe sensorineural hearing loss. Four patients had fractures at other sites.

Onset of Paralysis
Five patients had paralysis noted immediately after the trauma, 4 patients noted it to be delayed, and in 19 patients the time of onset could not be determined. The median time to presentation was 14 days.

Radiologic and Electrophysiologic Evaluations
A fracture in the temporal bone was seen in 26 patients; 24 patients had longitudinal fractures, 2 patients had transverse fractures (1 patient had combined longitudinal and transverse fracture), and in 2 patients no fracture was found. No significant displacement of the bony edges was seen in any of the fractures, and all fractures were judged as undisplaced or minimally displaced.

The most common site of involvement of the fallopian canal was in the region of the geniculate ganglion. The injury was localized to the labyrinthine segment in 1 patient, perigeniculate region in 13 patients, tympanic segment in 3 patients, and mastoid segment in 3 patients.

All initial evaluations had ENoG responses at less than 5% amplitude in comparison with the contralateral healthy side (unfavorable ENoG) and a universal EMG finding of “electrical silence” indicative of no neural-mediated muscle activity. On subsequent evaluations conducted at 4-week intervals, no
patient demonstrated further deterioration or denervation, as evidenced by fibrillation potentials. Early recovery could be detected on results of EMG by the presence of polyphasic motor unit action potentials, but these results did not predate clinical signs of recovery as noted by improving muscle tone and subtle movement.

Recovery of Facial Nerve Function
No recovery of facial paralysis was seen in any patient at the 4-week review. At the 8-week review, some initial signs of recovery were noted in 4 patients, and at the 12-week review some recovery was manifest in 27 patients (Table and Figure 1). The solitary patient demonstrating no improvement until the 18th posttraumatic week was scheduled for surgical exploration, but improved muscle tone and subtle facial movements were noted before surgery at the 20th posttraumatic week. Surgery was therefore deferred with the concurrence of the patient, and he continued with observation.

Recovery to HB grade I/II was attained in 4 patients by 12 weeks, 23 patients by 20 weeks, and 27 patients by 24 weeks (Table and Figure 1). On completion of observations at 9 months (40 weeks), 15 patients had attained HB grade I, 12 patients had attained HB grade II, and 1 patient had attained HB grade III. All patients with longitudinal fractures had demonstrated signs of some recovery by the 12-week review, and all recovered to HB grade I/II. The 1 patient with delayed and final grade III recovery had sustained a transverse fracture.

Facial nerve recovery as assessed by the FEMA grading system paralleled the findings as noted with the HB grading system (Figure 1B). At the 6-month follow-up 26 patients were at grade 0/1, and at 9 months 27 patients were at grade 0/1.

The modified Adour grading system, which also allowed for assessment of the quality of recovery and for synkinesis, showed a similar trend. At the final 9-month review, 26 patients were graded as good recovery (Adour score, 9-10) and 2 patients graded as partial recovery (Adour score, ≤8) (Figure 2). Synkinesis was present in 4 patients.

General congruence of assessment was noted between the 3 grading systems, with a congruence of 94.9% between the HB and FEMA observations and congruence of 91.9% between the HB and modified Adour observations. The incongruences in assessment between the grading systems were limited to a disparity of 1 grade.

Discussion
Early surgical exploration is the typically recommended treatment for patients with complete facial paralysis secondary to temporal bone fractures associated with unfavorable ENoG parameters. The evidence in support of this surgical dictum has, however, been weak, and to our knowledge, there are no available studies reporting on the natural history regarding recovery in such a scenario. Although a study evaluating the natural history alone is currently unconceivable, this
study examines the recovery rates with nonsurgical treatment with oral corticosteroids in a consecutive cohort of 28 patients, and notes that good-quality recovery—although delayed—is almost universal.

At the 9-month postinjury review 15 patients (54%) attained HB grade I and 12 patients (43%) attained HB grade II. The 1 remaining patient (with a transverse fracture) improved to HB grade III. A surgical comparison group is not included, but these results are comparable with and better than results from surgery as reported in large data sets by Nash et al\textsuperscript{11} in a systematic review of 340 patients (23% HB grade I, 58% HB grades II-V, and 9% HB grade VI), and by Bento et al\textsuperscript{10} in a single-institution data set of 156 patients with 1 year of follow-up (44% HB grade I, 36% HB grade II, and 20% HB grades III-V).

Patients with displaced fractures were not included, and those with transverse fractures formed a small minority. It would therefore be valid to generalize the results of this experience only to individuals with undisplaced longitudinal fractures of the temporal bone. Such fractures form the majority of temporal bone fractures, which is reflected in this study. All such patients with longitudinal fractures had recovery to HB grade I/II without surgical intervention.

Clinical assessments of facial nerve function were undertaken with the HB grading system, the FEMA assessment system, and the modified Adour assessment system. The HB grading system is the most widely used facial nerve grading system. The FEMA and Adour systems are more detailed than the HB system and encompass precise assessments and gradations of each facial region, as well as of any synkinesis. The FEMA system has been demonstrated to minimize interobserver variability in assessments compared with the HB system.\textsuperscript{21} A general congruity was noted in the results obtained from all 3 assessment systems (Figure 1 and Figure 2).

Electroneuronography is better termed evoked electromyography (EEMG), as it is a measurement of the EMG response of the facial muscles in response to facial nerve stimulation. Its limitations in the assessment of facial nerve pathologic conditions are well recognized.\textsuperscript{2,24} Electrical testing for most other nerves evaluates conduction at the site of the pathologic finding by stimulating the nerve proximal (or upstream) to the pathologic finding and measuring the conduction time and amplitude of response distal (or downstream) to the pathologic finding (eg, radial nerve testing in carpal tunnel syndrome). Facial nerve testing involves stimulating the nerve not proximal, but distal, to the site of pathologic finding in the temporal bone and trying to discern the extent of injury by the secondary effects it would have had in the distal axons downstream from the pathologic finding. This particular situation of distal stimulation creates an inbuilt anomaly on theoretical grounds itself, wherein prognostication is accurate for fibers in neurapraxia (ENOg responses positive and recovery likely) and neuronotemesis (ENOg responses negative and recovery unlikely), but inaccurate for fibers in axonotemesis (responses negative but recovery likely). The recovery noted despite poor ENOg responses, the general delay in recovery (8-12 weeks), and the synkinesis as noted in some patients indicate that axonotemesis may have been the dominant pathologic finding in the nerve fibers in these situations.

Criteria for ENOg and evoked EMG used by different clinicians as an indication for facial nerve decompression have ranged from 95% denervation alone\textsuperscript{6-10} to 90% to 95% denervation noted within the first few days of paralysis.\textsuperscript{2,24} As noted above, a lack of response to ENOg is, by itself, not an absolute indicator of poor recovery. Our study indicates that facial nerve recovery has been the rule even in patients with responses less than 5% of the contralateral side (ie, supposed >95% “degeneration”). This data set therefore indicates that in the current era with HRCT to rule out massively displaced fractures or dramatic impingement of the fallopian canal, the ENOg criteria of more than 90% to 95% denervation to select patients for surgical exploration is no longer valid.

The value of EMG was also noted to be limited, as in no patient was degeneration or fibrillation demonstrated on EMG results. Polyphasic muscle action potentials indicative of reinnervation were noted but did not predate clinical signs of recovery. The EMG, however, remains valuable in this situation, as it is the best tool to continue with monitoring for muscle denervation and injury progression. Although no such event was noted over the 4-month follow-up period for any patient, the investigation is useful in reinforcing the confidence of the patient and the physician that no progression or degeneration is ongoing. This is therefore helpful in “staying the course” with medical or nonsurgical treatment even if no signs of clinical recovery are immediately apparent.

The time of onset of facial paralysis (immediate or delayed) has also been used as a guide to nerve integrity, and, by corollary, to the necessity of surgery.\textsuperscript{5,11-13} It has, however, been our experience that such a history is usually not clearly available, and therefore cannot be used as a factor for decision making. In our study, this information was not available for 19 patients. However, all included patients demonstrated the unfavorable electrophysiologic features that are recommended as indications for surgical exploration.

The surgical option advocated is a complete exploration of the facial nerve along its intratemporal bony canal extending from the lateral end of the internal acoustic meatus to the stylomastoid foramen.\textsuperscript{2,20} The intent is for a nerve decompression to release any constricting neural edema, and an exploration of the nerve to identify and repair any nerve transections or impaling by a fracture segment. Such injuries leading to nerve transections or impaling can today be detected by HRCT, and surgery to merely explore the nerve does not seem
indicated in the current era. Further, such injuries leading to nerve transection or impaling are extremely unusual. In one of the largest surgical series to date encompassing 156 patients, Bento et al\(^2\) noted nerve edema in 147 patients, normal nerve in 8 patients, hematoma in 1 patient, partial section in 4 patients, and complete section in none. Conservative nonsurgical treatment can be expected to be effective in most such pathologic findings, as noted in this particular study.

In our study, recovery with medical treatment was invariably delayed. No patient demonstrated any recovery in the first 4 weeks, and all patients except 1 (with a transverse fracture) demonstrated the first signs of recovery 6 to 12 weeks after the fracture (Table). The studies reporting on early surgical decompression in the first 4 weeks and noting recovery thereafter are perhaps mistakenly crediting this delayed recovery to the effect of surgery. The overall rates of surgical improvement and the time course of improvement are no better than noted here with medical management alone. Initial patency rather than early surgical intervention would therefore seem prudent, with surgery to be considered only in the unlikely situations of no improvement in 4 months, or an obvious demonstration on imaging of nerve transection or impaling. This recommendation is in unison with the current treatment practices for injuries to other peripheral nerves such as the axillary nerve in humerus fractures.\(^1\)\(^-\)\(^1\)\(^8\)

Many surgeons harbor concerns—perhaps not fully articulated in the literature—with regard to the complications and morbidity of the middle cranial fossa approach for facial nerve decompression.\(^1\)\(^0\)\(^,\)\(^2\)\(^5\) A prospectively designed multicentric study on middle cranial fossa decompression for Bell paralysis was initiated with 14 centers but finally had compliance from only 3 centers.\(^2\)\(^4\) The rationale for the middle cranial fossa decompression has been noted as the ability to decompress the medialmost labyrinthine segment, which is deemed as most susceptible to compression and ischemia by dint of this being the narrowest part of the fallopian canal and also being a vascular watershed and relatively ischemic zone.\(^2\)\(^4\) One of the largest surgical series for middle cranial fossa facial nerve decompression has, however, advocated for a slight restriction of a full decompression with sparing of this very medial labyrinthine segment adjacent to the internal auditory meatus so as to reduce the risks of labyrinthine injury and sensorineural hearing loss.\(^3\)\(^0\) However, despite this modification, the incidence of significant adverse events was 14.7% (23 of 156 patients) inclusive of extradural hematoma in 4 patients, cerebrospinal fluid leak in 8 patients, meningitis in 4 patients, sensorineural hearing loss in 4 patients, and seizures in 3 patients. Such risks are not justifiable in light of the excellent prognosis with nonsurgical treatment, as reported here.

Previous recommendations on early surgical decompression have largely been based on expert opinion and single-arm retrospective case series\(^1\)\(^-\)\(^2\)\(^7\) and are reflective of the evidence base at that time. A reevaluation of these guidelines is required. It is hoped that this study would stimulate a reevaluation of these guidelines, as well as further studies to corroborate our findings.

Limitations
The population in this particular study is restricted to patients with undisplaced fractures, which consist mainly of longitudinal fractures. It would therefore be valid to generalize the results of this experience only to patients with undisplaced longitudinal fractures of the temporal bone.

Conclusions
Complete facial paralysis associated with temporal bone fractures and unfavorable EnoG findings is traditionally treated with surgical decompression. The experience in our study indicates this approach to be unjustified for undisplaced longitudinal fractures. Good-quality recovery with medical therapy, although delayed, has been noted to be universal. Initial conservative management with ongoing electrophysiologic monitoring would therefore seem prudent, with surgery to be considered only in the unlikely situation of no improvement during 4 months. For patients with transverse or oblique fractures, or those with significant displacement of the fractured segments wherein nerve transection may be suspected, clinical judgment should be exercised regarding surgical treatment or otherwise.