Conducting a Clinical Neurosensory Sensory Test (CNST) using the Three – Level Drop-Out Algorithm to a Patient in Study

Zuniga JR, Essick G. A contemporary approach to the clinical evaluation of trigeminal nerve injuries. OMFS Clin North Amer, 4:353-367, 1992

The purpose of conducting this NST is to obtain a sensory impairment score at this time (before and then compare your impairment scores at 3, 6, and 12 months) after your surgery to determine if you have recovered any functional or useful sensation.

The NST is a 3-level drop-out algorithm. Meaning that I will go through 3 levels of testing and stop only if you pass at any one level. I will be testing a small area of your chin on the right and left sides that is just above your chin button. I will try to stay in the middle of the chin on the right and left sides and not test your lip or jaw line or the inside of your mouth since the area I am testing represents the core/central innervation zone of the nerve . The testing should last less than 10 minutes and not cause you any harm.

The first level of testing includes 2 separate tests:

The first (BSDS brush stroke direction sensitivity) is to determine if you have any direction sensitivity on your chin. That is, if you have the ability to correctly identify direction of motion on the right and left sides of your chin.

To do this, I am going to use a q-tip (or brush) to stroke a small area of the right or left side of your chin on a horizontal axis. That is, I will move the q-tip (or brush) toward your right side or toward your left side on both sides of your chin randomly and each time I will ask you "what direction is the q-tip (or brush) moving **toward**". NOT what side I am on (the right or left side of your chin), but what direction is the moving q-tip (or brush) moving toward. Toward your right side *(pointing)* or toward your left side *(pointing).*

*For example, on your cheek (you can use right cheek side)." You can keep your eyes open. This is movement toward the right (*move q-tip or brush from the lateral nose to the right side of cheek about 1 cm of skin only)* and this is movement toward the left *(move q-tip or brush from the lateral cheek to the side of the nose on the same side)*."

I am going to do this randomly, that is I may move the q-tip to the right side on the right side (*pointing on your own chin)*, then to the left on the same side *(pointing on your own chin)*, then to the right side on the left side (*pointing on your own chin)*, and then go back to the right side, etc. Each time, I will ask you which direction is the q-tip (or brush) moving toward and you tell me what direction you feel it is moving toward.

I will throw in some “no-touches” s , so “I feel nothing” can be correct during this test.

I need you to close your eyes since “motion detection” helps “movement detection” and thus, keeping your eyes open is called “cheating”. Don’t cheat.

BEGIN – I PERFORM RANDOM MOVEMENTS FOR 15 PER SIDE IN 3 BLOCKS- DO 5 RIGHT AND 5 LEFT RANDOMLY IN WHATEVER ORDER AND DIRECTION YOU WANT AND THEN DO A “NO TOUCH”. REPEAT 5 RIGHTS AND 5 LEFTS AND AGAIN THROW IN A “NO TOUCH” AND THEN REPEAT 5 RIGHT AND 5 LEFTS RANDOMLY- **YOU ARE DONE.** *COUNT THE NUMBER OF CORRECT OVER 15 FOR A PERCENTAGE CORRECT TO REPORT BSDS RESULTS ON THE RIGHT AND LEFT SIDES.* ***ONE MISS IS ALLOWED (93.3%) TO BE NORMAL RANGE. ANYTHING < ONE MISS IS “ABNORMAL” AND MOVE ONTO 2ND LEVEL TESTING BUT COMPLETE 2PDT***

The next test in the first level is called two-point discrimination, in other words, I want to know if you have the ability to distinguish one point from two points touching your chin in the same location I just tested.

To do that, I am going to use a Boley Gauge (*show them the Boley gauge or equivalent “discriminator”)*. I can take the Boley gauge and change the distance between the two calipers and know exactly how far apart the two calipers are in millimeters.

*For instance, if I put the two caliper points together and touch a spot on your right cheek, like this (*lightly touch the right cheek with boley gauge points together or the single point on the discriminator)*, you should feel ONE POINT. Now, if I separate the caliper points (*about 20mm)* and touch the same spot on your right cheek, like this (*lightly touch the right cheek with boley gauge points separated by at least 20mm or the 20mm mark on discriminator)*, you should feel TWO POINTS.

State: “ONE POINT, TWO POINTS” (*until they get it)*

I will start out a with a certain distance between the two caliper points and touch your chin and each time say “IS THIS ONE POINT OR TWO POINTS”, and each time you tell me ONE or TWO depending on what you feel. Each time you say ONE, the next time I touch your chin I will increase the distance between the calipers until you say TWO. Once I get you to say TWO, I will decrease the distance between the two caliper points until I get you to say ONE, then back to TWO, then down to ONE, back to TWO, down to ONE until I get a threshold. That is, the millimeter distance below of which you called it ONE, just above of which you called it two.

Unlike the last test which was not a threshold test (referring to BSDS) this test will measure your two-point discrimination threshold (2pdt). The reason why I am telling you this, is that you will have sensations that you are sure it is ONE POINT and hopefully sensations that you are sure it is TWO POINTS. But, sometimes you will have sensations that you are not sure, might feel like one or two or other. That is because you are close to threshold. If you are “in this zone”, call it a ONE, in other words, don’t call it TWO unless you are **sure** it is TWO POINTS.

Also, unlike the last test which I did randomly over the 2 sides, I am going to test one side at a time and test the ____ side first (*the side of the injury)* and then the other side. But, like the last test, I will ask you to close your eyes since you could see me change the boley gauge during the testing.

BEGIN- START AT 10MM DISTANCE. USE THE "2 DOWN-ONE UP RULE ". THEY HAVE TO GET 2 IN A ROW CORRECT AT SAME DISTANCE BEFORE GOING DOWN AND GO UP IF THEY MISS 1 OF 2. THE VALUE COLLECTED IS THE MM OF THE 'TURN AROUND'.

FOR EXAMPLE:

1. START AT 10MM – THEY SAY ONE

2. GO TO 11MM – THEY SAY TWO

3. STAY AT 11MM – THEY SAY ONE

4. GO TO 12MM – THEY SAY ONE

5. GO TO 13MM – THEY SAY TWO

6. REPEAT AT 13MM- THEY SAY TWO

7. GO TO 12MM – THEY SAY ONE = *THIS IS THE 'TURN AROUND' VALUE WHICH YOU RECORD*

8. GO TO 13MM – THEY SAY TWO

9. REPEAT 13MM – THEY SAY ONE

10. GO TO 14MM – THEY SAY TWO

11. REPEAT 14MM – THEY SAY TWO

12. GO TO 13MM – THEY SAY ONE = *THIS IS YOUR NEXT 'TURN AROUND' VALUE WHICH YOU RECORD*

DO THIS FOR 5 'TURN AROUNDS' – REPORTING VALUE IS THE AVERAGE OF THE LAST 4 'TURN AROUNDS' – THROW OUT THE FIRST (AS OFTEN A TEST VALUE AS SUBJECT ADJUSTS TO THRESHOLD)

FOR THE CHIN, ANYTHING BELOW 18MM IS ACCEPTABLE AS PASSING. ANYTHING ABOVE 18MM IS FAILING –

IN LEVEL A: THEY HAVE TO "PASS" BOTH BSDS AND 2PDT BEFORE STOPPING. If they fail one or both, go on to LEVEL B:

The next level of testing is called CONTACT DETECTION: that is, I want to know if you can feel contact or not on the same area of the chin I just tested.

To do that, I am going to use a box of filaments or probes (*show them a larger monofilament and touch your hand)* saying this is not a needle or pin but a probe AND if I touched your cheek (*touch their cheek lightly)*, you should feel "CONTACT"

Now, I have a box of these probes back here and each probe has a number on it. At one end of the box (referring to the 2.0 end) the number is small because the filament is so small that you can hardly see it since it is the size of a human hair. On the other end of the box (referring to the 6.0 end), the number is large, because the filament is large, like the bristle on a hair brush. What I am trying to do is measure your threshold to feel contact. Back to threshold.

Now, if I did yes-no, yes-no for each size probe, we will be here all day. Rather, I am going to use the "two alternative forced choice" task for each probe. That is, for each probe, I am going to give you two numerical ques. I am going to say "this is number ONE", "pause" and then say "this is number TWO" I will be touching you when I call out one of the numbers but not on the alternative. Your task is to tell me the number (ONE OR TWO) that you associate with the touch.

*For instance, on your right cheek (*tell them to keep their eyes open, use a 4.0 size filament which is above threshold)* take filament and touch the cheek and say "this is number ONE", pause a couple seconds, then don't touch the cheek when you say "this is number TWO" the answer that time is ONE. Now, an alternative test is don't touch the cheek and say "This is number ONE", pause a couple seconds, then touch the cheek and say "this is number TWO". Say "What is the correct answer?"– if they say ONE, then repeat it and alternate until they "get it". If they say TWO, they likely "get it".

Then I say: "I'm not going to play with you and touch you both times or not touch you both times, but will touch you once when I call out the 2 numbers; that's why they call it "two-alternative forcing you to make a choice".

However, I am going to start out on the 'small number' side of the box which you may not be able to feel anything, even on the normal side and go up and up on both sides until I get you to correctly identify the touch. And the, go down and down until the sensation of touch goes away. The average is your threshold.

I am going to do this randomly like the first test we did (referring to BSDS) and will ask you to close your eyes so you don't see the movement. Ready, here we go

START AT THE FAR LEFT OF BOX (1.65), TEST BOTH RIGHT AND LEFT SIDE RANDOMLY BUT USING TWO-ALTERNATIVE FORCED CHOICE PARADIGM DESCRIBED ABOVE. You will collect two values – the ascending number is the lowest of 2 prove values in a row they correctly identified the probe contact number going from left to right (ascending order). Then the descending value is the highest of 2 probe values in a row they incorrectly identified the probe contact on the right and left sides. THE REPORTED CD VALUE IS THE MEAN AVERAGE OF THE ASCENDING AND DESCENDING VALUE

A VALUE 2.84 OR LESS IS NORMAL

A VALUE GREATER THAN 2.84 IS ABNORMAL AND MOVE ONTO LEVEL C testing

The next level of testing is to determine your Pain threshold and tolerance values without hurting you.

To do that, I am going to use pressure to deliver pain without hurting you. The reason why pressure is a good stimulus is that light pressure doesn't hurt – just feels like pressure, but as you deliver greater pressure there is a point in which it becomes painful for everyone regardless of where you apply it.

This is a pressure algometer (*show them the algometer)* and put it on your hand or finger and show them the meter and push the plunger in so they see the dial increase, then say. The dial shows me how much pressure in pounds (or kilograms) I am delivering to my hand (or finger). It doesn't hurt when I start but if I keep putting more pressure on it will.

I am going to measure your pressure pain threshold and tolerance on your chin in the same sites as the other tests but I want to test the volar surface of your wrist first so you understand what I am trying to measure and how.

Have them extend their right hand/wrist and place the plunger lightly on the skin of volar surface and say. I am going to ask you to "raise your left hand when it is first perceptibly painful", that is when the pressure which doesn't hurt suddenly becomes a little painful. I will note the pounds of force that it took to get there. Then I will say "raise your left hand when you want me to remove it", that is "that's it, no more" and I will remove it and record the value. The first time you raised your hand, that is your pressure pain threshold and the second time you raised your hand, that is your pressure pain tolerance.

*perform the task until they can clearly separate the two sensations

Now, I am going to do this test on your chin (same location) and do the _____ side first (the side of nerve injury or soon to be nerve injury) and then the other side. You can keep your eyes open, since you seeing movement will not affect the results.

PERFORM THE TEST ON THE INJURED SIDE FIRST, THEN THE NORMAL SIDE. THEN REPEAT. COLLECT THE THRESHOLD AND TOLERANCE VALUES ON BOTH SIDES, TAKE THE AVERAGE AND REPORT THE TWO VALUES PER SIDE

PPTHRESH (PRESSURE PAIN THRESHOLD): normal = 0.75lb to 1.5lb

PPTOL (PRESSURE PAIN TOLERANCE) : normal = 1.5lb to 2.5 lb

YOU ARE DONE WITH THE ALGORITHM

Table 1: MR Neurography Protocol on a 3-T Imaging Unit

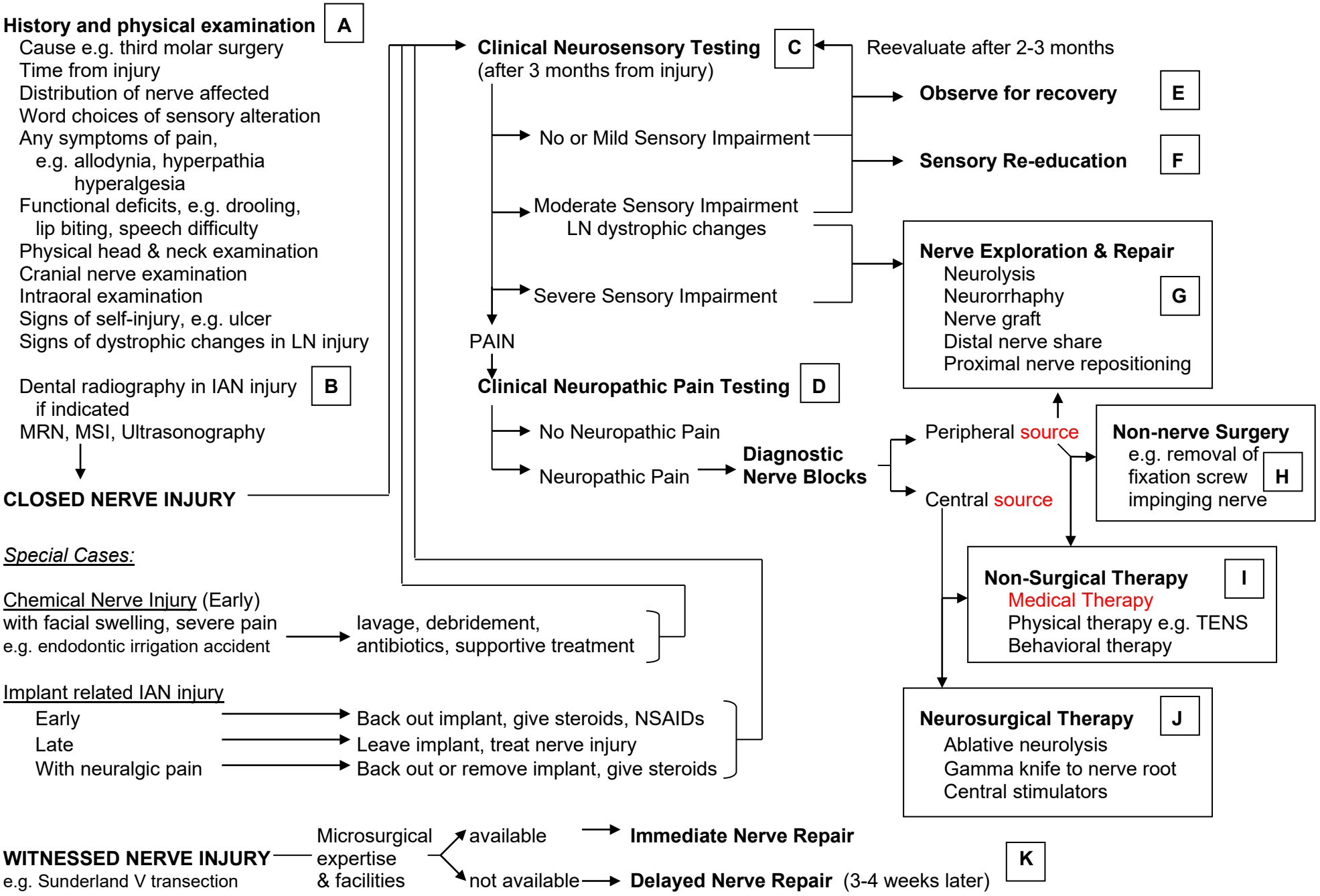
Sequence	TR/TE (msec)	Section Thickness (mm)	Matrix	FOV (cm)	Comments	Acquisition Time (min: sec)
Axial T2W SPAIR	2,000/60	3.0	268 x 248	16	Corpus callosum to chin	5:20
Axial T1W	580/9	3.0	320 x 310	16	Corpus callosum to chin	5:10
Axial 3D balanced FFE	5.32/2.66	0.65	270 x 270	16	Corpus callosum to chin	6:00
Axial DTI	14,000/70	5.0	196 x 192	18	Skull base to chin; b values = 0 and 600 sec/mm2; 12 directions	7:00
Coronal 3D STIR	1,500/78	1.5 (isotropic voxel)	…	20	Corpus callosum to chin	7:15
Coronal 3D PSIF	12/2.5	0.9 (isotropic voxel)	…	20	Corpus callosum to chin	7:30

Abbreviations: DTI, diffusion tensor imaging, FFE, fast field echo; FOV, the field of view; SPAIR, spectral attenuated inversion recovery; TE, echo time; T1W, T1-weighted; T2W, T2-weighted; TR, repetition time

Table 2: Sunderland Nerve Classification Stratified by Clinical NST/MRCS Grade, Surgical Findings, and MRN Imaging

Sunderland Classification	Clinical NST Level and MRCS Grade Description	Surgical Findings by Direct Inspection	MRN Findings
I	Normal (4)/S3+ or S4 by 3 months	Intact with no internal or external fibrosis, normal mobility, and neuroarchitecture (visualized fascicles and Fanconi bands)	Anatomic: homogenous, mild increased T2W nerve signal
II	Normal (4)/S3+ or S4 by 6 months	Intact with no internal fibrosis; external fibrosis, restricted mobility, but neuroarchitecture intact (visualized fascicles and Fanconi bands once external scar removed)	Anatomic: homogenous increased T2W signal of nerve and mild nerve thickening or constriction; perineural fibrosis
III	Mild (3) or moderate (2)/S2, S2+, S3 by ≥6 months	Intact with both internal and external fibrosis, restricted mobility, and disturbance of neuroarchitecture (abnormal fascicle patterns and/or Fanconi bands not visible)	Anatomic: homogenous increased T2W signal of nerve and moderate thickening or constriction; perineural fibrosis
IV	Moderate (2) or severe (1)/S1, S2, S2+ by ≥6 months	Partially transected nerve but some amount of distal nerve present with or without neuroma in continuity.	Anatomic: homogenous increased T2W signal of nerve and moderate thickening or constriction; perineural fibrosis
V	Severe (1) or complete (0)/S0, S1 by ≥6 months	Completely transected nerve with or without amputation neuroma	Anatomic: discontinuous nerve with end-bulb neuroma

Abbreviations: MRCS, Medical Research Council Scale, MRN, magnetic resonance neurography; NST, neurosensory testing, T2W, T2-weighted


History and physical examination
A
Cause e.g. third molar surgery
Time from injury
Distribution of nerve affected
Word choices of sensory alteration
Any symptoms of pain,
e.g. allodynia, hyperpathia
hyperalgesia
Functional deficits, e.g. drooling,
lip biting, speech difficulty
Physical head & neck examination
Cranial nerve examination
Intraoral examination
Signs of self-injury, e.g. ulcer
Signs of dystrophic changes in LN injury
Dental radiography in IAN injury
if indicated
B
MRN, MSI, Ultrasonography
CLOSED NERVE INJURY
Special Cases:
Chemical Nerve Injury (Early)
with facial swelling, severe pain
e.g. endodontic irrigation accident
lavage, debridement,
antibiotics, supportive treatment
Implant related IAN injury
Early
Late
With neuralgic pain
Back out implant, give steroids, NSAIDs
Leave implant, treat nerve injury
Back out or remove implant, give steroids
WITNESSED NERVE INJURY
e.g. Sunderland V transection
Microsurgical
expertise
& facilities
available
not available
Immediate Nerve Repair
Delayed Nerve Repair (3-4 weeks later)
K
Clinical Neurosensory Testing
C
(after 3 months from injury)
No or Mild Sensory Impairment
Moderate Sensory Impairment
LN dystrophic changes
Severe Sensory Impairment
PAIN
Clinical Neuropathic Pain Testing
D
No Neuropathic Pain
Neuropathic Pain
Diagnostic
Nerve Blocks
Reevaluate after 2-3 months
Observe for recovery
E
Sensory Re-education
F
Nerve Exploration & Repair
Neurolysis
Neurorrhaphy
Nerve graft
Distal nerve share
Proximal nerve repositioning
G
Peripheral source
Central source
Non-nerve Surgery
e.g. removal of
fixation screw
impinging nerve
H
Non-Surgical Therapy
I
Medical Therapy
Physical therapy e.g. TENS
Behavioral therapy
Neurosurgical Therapy
J
Ablative neurolysis
Gamma knife to nerve root
Central stimulators

MANAGEMENT ALGORITHM OF TRIGEMINAL NERVE INJURY

A. Most Inferior Alveolar Nerve (IAN) and Lingual Nerve (LN) injuries are closed, or unwitnessed, so that the clinician does not know the degree of injury nor can distinguish between a recoverable injury versus an injury with a poor prognosis of recovery without nerve repair. A **history and physical examination** is conducted and includes obtaining the following information[1]: 1. **Cause of injury** (e.g., odontectomy, orthognathic surgery are often associated with mechanical injuries, postinjection injuries are chemical injuries); 2. **Time from injury** (e.g., neurosensory tests cannot adequately distinguish between degrees of injury within 1 month of the injury, while injuries older than 1 year have poor prognosis for recovery from any known treatment); 3. **Distribution of injury** (e.g., complete dermatome deficit suggests trunkal injury versus partial dermatome which suggests incomplete injury often associated with postinjection injuries); 4. **Word choices** to describe sensory alteration (e.g., pain, burning, pricking are often used by patients with neuropathic pain conditions); 5. **Functional deficits** (e.g., loss or decreased taste may indicate a more severe injury of the lingual nerve that may improve with microsurgery, while abnormal taste (dysgeusia) may indicate central dysfunction that has a poor prognosis for any known treatment). **Head and neck, cranial nerve and intraoral examinations** may provide information about the degree of injury. **Signs of self-induced injury** (e.g., traumatic lip/ cheek/tongue fibroma may indicate denervation of the area), **dystrophic changes** of the tongue[2] (e.g., loss of fungiform papilla/pores indicates severe injury of the lingual nerve), **trigger responses** (an abnormal sensation caused by the manual stimulation of the nerve injury) found in the paralingual sulcus usually indicates the presence of a traumatic neuroma of the LN.

B. **Postinjury Imaging** includes primary and secondary phase imaging; primary (e.g., after nerve injury without microsurgery) and secondary (e.g., after surgical nerve repair or exploration)[3]. A panoramic radiograph may demonstrate presence of foreign bodies, removal of bone in proximity of IAN canal, association of tooth roots to IAN canal[4]. High-resolution magnetic resonance imaging (MRI), magnetic resonance neurography (MRN), magnetic source imaging (MSI) and ultrasonography may provide additional information about nerve location, continuity and pathology[3]

Special situations that may require urgent intervention include endodontic therapy-related injury and implant surgery-related injury of the IAN. Chemicals or material such as sodium hypochlorite or calcium hydroxide forced beyond the tooth apex into the mandibular canal should be removed by lateral decortication, lavage and debridement as soon as possible[5]. Implants should be backed out if there is radiographic evidence that the implant may be violating the mandibular canal in the early period following implant placement surgery[6]. Steroids or anti-inflammatory agents may be prescribed.

C. **Clinical Neurosensory Testing** is used to provide a diagnosis, prognosis and treatment option for the patients altered sensation. One clinical neurosensory test (CNST) is the 3 level drop-out algorithm[1]. Patients with No or Mild Sensory Impairment by 3 months from the time of injury are observed for recovery with a good prognosis for recovery within 1 year. Patients with Moderate Sensory Impairment have a fair prognosis for recovery within 1 year and may benefit by

sensory retraining (e.g., sensory re-education), but may also benefit by surgical intervention if painful neuromas are present. Patients with Severe or Complete Sensory Impairment have poor prognosis for recovery and are candidates for microsurgery.

D. In the presence of pain (e.g., dysesthesia), in addition to the CNST, a 4 level **Clinical Neuropathic Pain Testing** (CNPT) exam is performed to distinguish allodynia, hyperpathia, hyperalgesia, anesthesia dolorosa, peripheral and central-sources of the neuropathic pain[1]. The 4th level of testing includes **diagnostic nerve blocks** to help distinguish potential nervous system sources of the pain[7]. The resolution of the subjective and objective pain complaints with trigeminal nerve blocks suggests that the source is peripheral (trigeminal nerve exploration and repair resolves the pain in up to 70% of cases). The failure to affect the pain complaint with trigeminal nerve blocks suggests a central source (trigeminal nerve exploration and repair are never beneficial and may be harmful).

E. Non-painful nerve injuries with No or Moderate Sensory Impairment consistent with a Sunderland I to III degree nerve injury may be **observed for recovery**.

F. **Sensory Re-education** may be beneficial for patients with subjective sensory alteration, in particular those with sensations of tingling or pins and needles. Sensory re-education should begin soon after the injury and continue for 12 months[8].

G. **Nerve Exploration and Repair** of the IAN and LN include neurolysis (external and internal), neurorrhaphy (direct repair of coapted ends), nerve graft (indirect repair using autogenous, homologous or alloplastic materials), and nerve share ("sharing" the greater auricular nerve with the mental nerve using a sural nerve graft). Proximal nerve repositioning in muscle may be necessary if the distal nerve segment cannot be found[9-12].

H. **Non-nerve Surgery** may be applicable in the presence of a foreign body impinging on a nerve, e.g., removal of a fixation screw.

I. **Non-Surgical Therapy** includes 3 options: (1) medical treatment with anticonvulsants, antidepressants, opioids, antiarrythmics, topicals; (2) physical therapy with transelectrical nerve stimulation (TENS); or (3) behavioral therapy with hypnosis, imaging, etc[13,14].

J. **Neurosurgical Therapy** has been advocated for recalcitrant trigeminal neuropathic pain conditions and include ablative neurolysis, gamma knife lesions of the trigeminal root, and central stimulators. The benefits of these procedures for post-injury trigeminal neuropathic pain is not clear[15].

K. **Witnessed Injuries** of the IAN and LN (the clinician visualizes the injury and the degree of injury) have the best outcomes if treated immediately. Immediate nerve repair may be undertaken if microsurgical expertise is available; otherwise delayed nerve repair may be planned for within 4 weeks of injury[16]. Supportive non-surgical methods serve as an alternative option.

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Review Article

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REVIEW ARTICLES

A Comprehensive Algorithm for Management of Neuropathic Pain

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