Clin Oral Invest (2007) 11:133–142
DOI 10.1007/s00784-006-0089-5

ORIGINAL ARTICLE

Iatrogenic injury to oral branches of the trigeminal nerve: records of 449 cases

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Received: 13 March 2006 / Accepted: 2 November 2006 / Published online: 22 December 2006

Abstract The aims of this study were threefold: (1) to describe iatrogenic lesions to oral branches of the trigeminal nerve, signs and symptoms, and functional status, (2) to report on a simple neurosensory examination method, and (3) to discuss means of prevention of iatrogenic injury. The etiology and functional status of 449 injuries to oral branches collected over 18 years were retrospectively reviewed. A simple scheme of a clinical neurosensory examination was applied to enable a quantified rating of the perception. Injury to the lingual nerve (n=261) is not only the most prevalent type of lesion, it also seems to be the most devastating type of lesion. Third molar surgery (n=319) counts for the majority of injuries to the lingual, inferior alveolar, and buccal nerves. Lesions related to the injection of local analgesics was the second most frequent etiology (n=78), and the lingual nerve was affected more frequently and severely than other oral branches of the trigeminal nerve. The female gender was overrepresented in incidence of injured nerves but no difference was found in the severity of affection between females and males. All grades of loss of neurosensory functions were found, and a range of neurogenic malfunctions was reported. Methodological obstacles in clinical neurosensory examination of trigeminal nerve injury and the magnitude of neurosensory impairment are discussed. Many nerve injuries are avoidable by critical reevaluation of indications, increased awareness of potential hazards, and modified surgical procedures.

Keywords Nerve injury · Trigeminal nerve · Third molar surgery · Etiology · Iatrogenic

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Introduction

Iatrogenic injury to oral branches of the trigeminal nerve may cause a debilitating loss of function and the full range of unpleasant and potentially painful neurogenic malfunctions in the oral and maxillofacial region [22]. Such injuries are unintentional and at most unsuspected, and they may have a profound impact on the quality of life of the subjects affected, be painful to patients and doctors alike. The latter aspect is not only addressing the embarrassment of causing damage but it also relates to an increased focus on patients' complaints, litigation, and malpractice suits [5, 24, 38].

The true incidence of iatrogenic trigeminal nerve injury is difficult to establish because such injury may be caused by a variety of different treatment modalities such as major maxillofacial and minor oral surgery, implant treatment [21, 41], injection of local analgesics [19], mishap of instrumentation during preparation, and endodontic treatment [13]. Disregarding iatrogenic nerve injuries in major maxillofacial surgery that may be unavoidable and may constitute an accepted risk with informed consent, third molar surgery is counting for the highest incidence of nerve injuries [3, 4, 9, 23] followed by other modalities of treatment. Mason [25] found in a prospective study an incidence of temporary and permanent alteration of sensation after third molar surgery of 11.5% and 0.6%, respectively.

Injection lesions involving the lingual and inferior alveolar nerves are rare, but still injection injuries may affect the patients' quality of life significantly [19, 27]. Estimates indicate a prevalence of temporarily impaired lingual and inferior alveolar nerve function ranging in the order of size of 0.15–0.54% [16, 20], whereas permanent injury caused by injection of local analgesics is much less frequent, 0.0001–0.01% [14, 16, 27], depending on mode of data collection, type of sample, etc. Inferior alveolar nerve injuries as a complication to implant treatment is becoming a major concern [21, 42] and incidence studies indicate a complication rate not to be ignored [2, 7]. Likewise, endodontic procedures may, though rarely, inflict serious damage to be dealt with [13].

Liability claims and malpractice suits are inherent risks associated with iatrogenic nerve injury [5, 15, 38] and the reasons for avoidance of such injury are obvious. Iatrogenic nerve lesions may produce symptoms ranging from next to nothing to a devastating affection of quality of life. Only few studies, however, describe the range of neurosensory disturbance in terms of signs and symptoms related to impaired nerve conduction and neurogenic affliction [6, 29, 43], and there is a need for better standardization and documentation of sensory deficits resulting from nerve injuries and their recovery [8].

The aims of this study are:

– To describe lesions to oral branches of the trigeminal nerve in terms of signs and symptoms and functional status related to etiology and gender.
– To report on a simple neurosensory examination method that allows a reliable assessment and documentation of sensory deficit.
– To discuss means of prevention of injury to oral branches of the trigeminal nerve.

Materials and methods

The period of data collection ranged from 1987–2005. Four hundred sixty-seven patients were consecutively referred to and examined by the author at two Copenhagen University hospitals (Glostrup Hospital, 1990–2001, and Rigshospitalet, before 1990 and after 2001) (Fig. 1). Referrals were obtained from dental and medical colleagues and from the Danish Dental Association's Patient Insurance Scheme covering all dental practitioners in Denmark (DK). Most patients were treated in general dental practice.

Criteria for inclusion in the present study Iatrogenic, unilateral injury to oral branches of the trigeminal nerve caused by minor oral surgery, injection of local analgesia, or dental treatment.

Criteria for exclusion Neurological disease, known alcoholism, injury caused by major OMFS, and patients with bilateral injuries. On this basis, 18 individuals were excluded, and the patient sample comprised 449 nerve injuries, 328 (73.1%) in female patients and 121 (26.9%) in males. Their median age was 36 years (range 16–83 years).

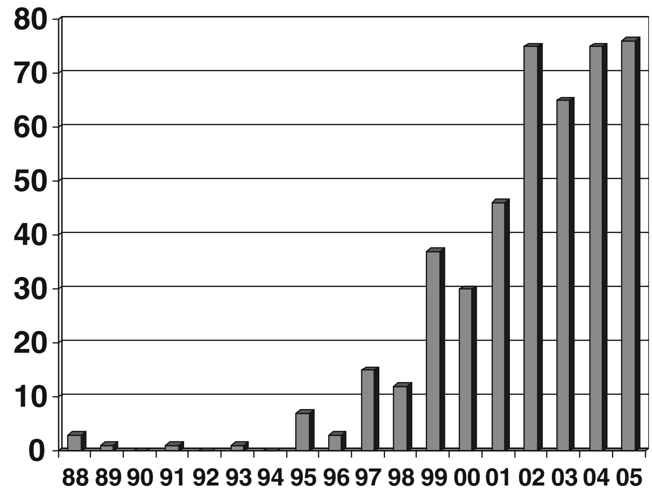

Fig. 1 New referrals of patients with iatrogenic injury to oral branches of the trigeminal nerve during the data collection period from 1987–2005

Neurosensory evaluation—interview and clinical examination

All patients were examined according to a standardized test of neurosensory functions [18, 29, 33] by the same observer (SH) to clarify the subjective and objective neurosensory status of the injured nerve. A printed record form was used.

Interview A history was taken to include the date and mode of injury and the patients' self assessment of neurosensory function in terms of reduced function (hypesthesia, anesthesia), and neurogenic discomfort (paresthesia, dysesthesia, allodynia, dysgeusia, ageusia, etc.) (Appendix). Associated discomfort or malfunction was frequently reported. Examinations took place in a quiet room with the patients best possible at ease, and they were urged to concentrate on the neurosensory test.

The patients were requested to assess their overall level of sensory function of the affected nerve on a simple rating scale ranging from 0–3 [0 = no perception of touch, 1 = perception of touch with no ability to differentiate (pointed/blunt, warm/cold, localization of touch, direction of moving touch), 2 = perception with ability to differentiate less clear than normal, and 3 = normal perception].

The rating of specific functions listed below related to the same scale, 0–3, and all assessments/ratings were based on a comparison with the uninjured side.

Clinical examination The clinical examination was inspired by Robinson et al. [33] utilizing a simple kit of instruments (Fig. 2) and each of the following neurosensory qualities

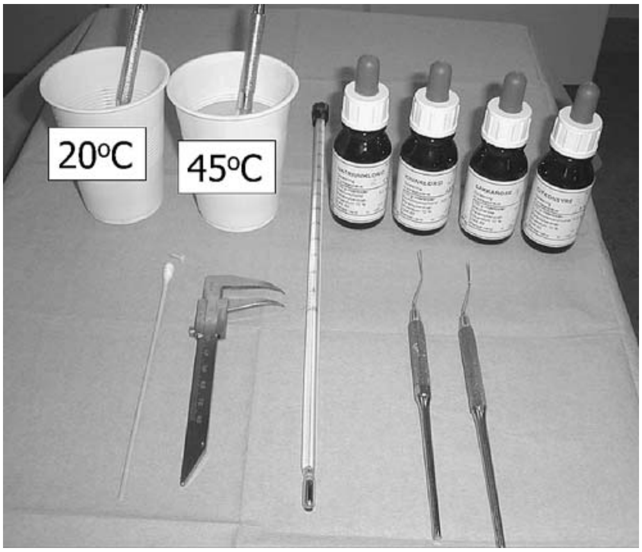

Fig. 2 Simple kit of instruments for clinical neurosensory examination of oral branches of the trigeminal nerve

were addressed and scored as explained with a rating from 0–3:

1. Feather light touch—The extruded filaments of a cotton stick were gently pulled over the area to be examined (Fig. 3a).
2. Pin prick—the pointed end of a dental probe was gently touching the area to be examined with minimal pressure (Fig. 3b).
3. Pointed/dull discrimination—the pointed and dull ends of a dental probe were gently touching the area to be examined with minimal pressure (Fig. 3b,c).
4. Warm—the handle of a dental mirror was warmed up in 45–50°C water, wiped dry, and the patient's ability to recognize warm was tested (Fig. 3c).
5. Cold—the handle of a dental mirror was cooled in 0–20°C water, wiped dry, and the patient's ability to recognize cold was tested (Fig. 3c,d). It was recognized during the data collection that 0°C might trigger pain receptors, and hence tap water of 20°C was subsequently employed.
6. Localization of touch—a mutual understanding of "in the back", "in the middle", and "near the tip" of the tongue was introduced in the healthy side, and tested in the injured side in patients with lingual nerve lesions. Likewise, when examining the inferior alveolar nerve, the concepts of "near the lip", "near the chin", and "in the middle" were introduced and demonstrated in the healthy side before testing the injured side (Fig. 3e).
7. Brush stroke direction—a blunt instrument was gently drawn in a direction that would be recognized immediately in the healthy side (forwards, backwards, towards the middle, towards the side), and tested in the injured side (Fig. 3f).
8. Two point discrimination thresholds—a pair of calipers was employed, and the patients' ability to discriminate was tested with 20, 15, 10, and 5 mm (Fig. 3g).
9. Pain protective reaction—in patients giving no or questionable response to the tests 1–8, and with the patients informed consent, a painful stimulus was produced by squeezing the area in question with a tissue forceps. A blink reflex or a protective reaction was interpreted as retained pain perception.
10. Patients with injury to the lingual nerve were examined for the presence of a traumatic neuroma. An unpleasant, irradiating sensation in the injured side of the tongue induced by digital pressure to the region of suspected injury at the medial aspect of the mandibular ramus was interpreted as caused by a traumatic neuroma.
11. Dentate patients with injury to the inferior alveolar nerve were tested for side differences of threshold values on electric pulp stimulation employing a "B 1000 Pulp pen" yielding an adjustable, pulsating current 0–250 μA, wavelength 10 ms, and a frequency of 6 Hz.

The level of neurosensory function was characterized through the sum of scores that might range from 0–21, score 0 signifying a total loss of nerve conductivity, and score 21 denoting normal neurosensory function of the nerve in question.

In 12 patients from the first years of data collection, the neurosensory examination described was performed only after the initial examination.

Statistics

Side differences between the healthy and the injured side were tested with Students' *t* test, and a Chi-square test was applied for nonparametric testing of frequencies. A "sign test" was applied to binomial distributions. The value of $p \leq 0.05$ was chosen as level of significance. The software used was the EPI6 program package for DOS. Illustrations were produced with the help of the Microsoft Office 2003 program package.

Results

Epidemiology

Incidence of referrals Patients were referred from all parts of the country of DK, and there was a significant increase

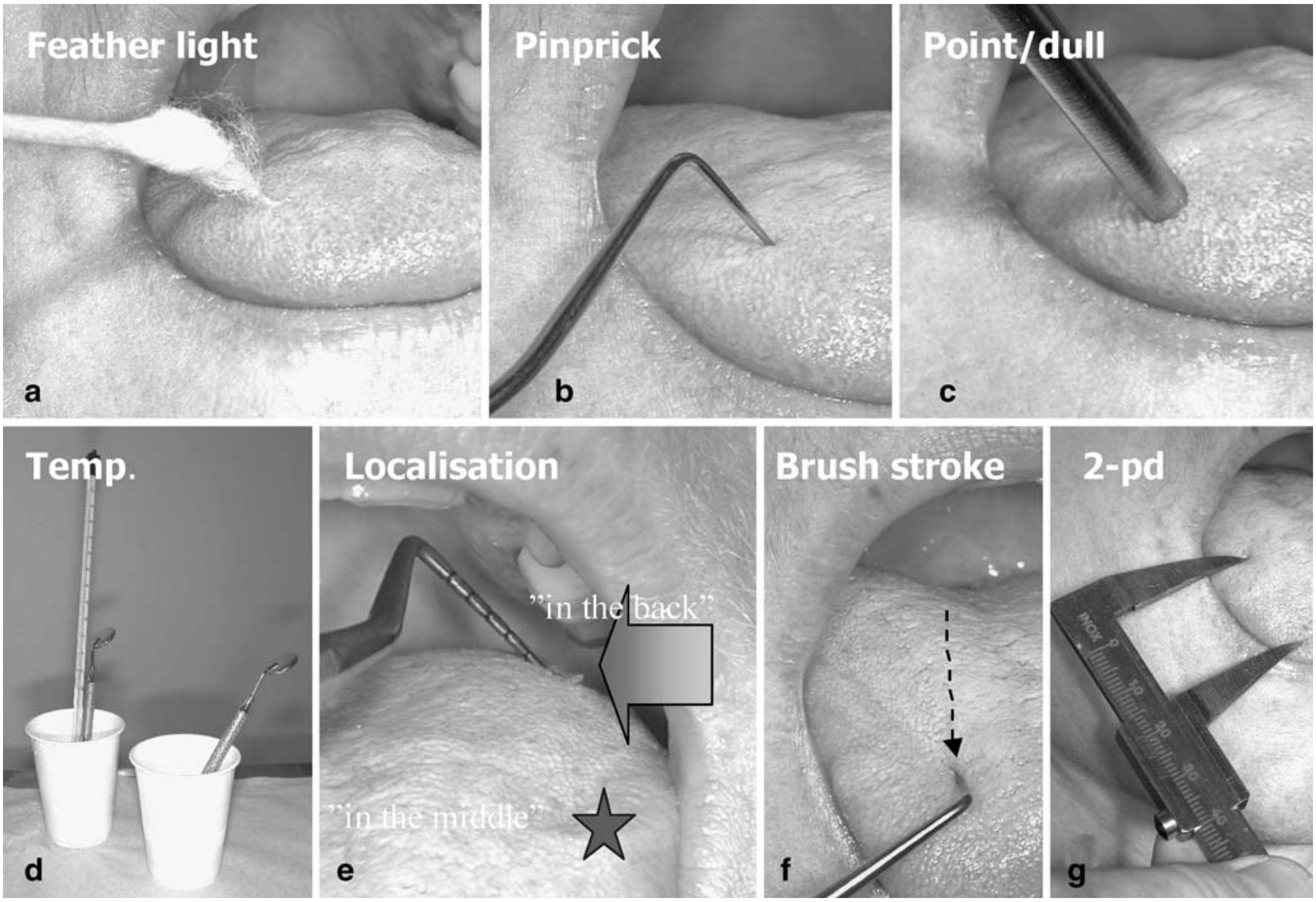

Fig. 3 Clinical examination of perception of tactile and thermal stimuli, and perception of touch location, brush stroke direction, and two-point discrimination

of referrals over the long period of data collection from 1987–2005 as shown in Fig. 1.

Time from injury to examination followed a skew distribution with an arithmetic mean of 14.5 months (SD 28.0), and a median value of 8 months, range 0–430 months. Most patients were seen within a year after the injury.

Nerve involved The distribution of injured nerves shows a clear dominance of the lingual nerve, (n=261; 58.1%), followed by the inferior alveolar nerve (n=149; 33.2%), and the buccal nerve (n=32; 7.1%) (Table 1). The mental, infraorbital, and palatal branches were only infrequently involved (n=7; 1.6%). Considering the distribution of injuries related to gender, a significant female overrepresentation is evident, p=0.0000. Sidewise, trigeminal branches of the right side were affected in 234 patients (52.1%) and the left side was stricken in 215 (47.9%; ns).

Etiology Third molar surgery was by far the most prevalent cause of injury (n=319) totaling 71.0% of the material (Table 2). All three trigeminal branches in the third molar region may be injured, the lingual nerve (n=196; 61.1%), the inferior alveolar nerve (n=94; 29.8%), and the buccal nerve (n=29; 9.1%).

Surprisingly, perhaps, injection injuries came in second with 78 cases (17.4%) followed by dentoalveolar surgery (n=17; 3.8%), implant surgery (n=16; 3.6%), endodontic treatment (n=10; 2.2%), and other/unknown (n=9; 2%). Injuries related to dentoalveolar surgery other than third molar surgery were more incidental with no typical pattern of emergence. They were associated with cystectomy, apicoectomy, tooth transplantation, minor bone graft augmentation, etc.

Other causes include three cases of lingual nerve lesions whereby two were caused by a rotating instrument hitting the floor of the mouth, and one case of hard laser treatment for third molar pericoronitis. A female overrepresentation was mirrored also in the groups of different etiology.

Signs and symptoms—nerve function

Subjective symptoms During history taking, the patients were requested to report as detailed and specific as possible on the nature of their neurosensory impairment, and their response

Table 1 Distribution of 449 iatrogenic injuries to oral branches of the trigeminal nerve by gender

Nerve branch	Female	Male	Total	Percentage	P value[a]
Lingual nerve	180	81	261	58.1	<0.0001
Inferior alveolar nerve	116	33	149	33.2	<0.0001
Buccal nerve	27	5	32	7.1	0.0001
Mental nerve	1	2	3	0.7	ns
Infraorbital nerve	3	0	3	0.7	ns
Palatine major nerve	1	0	1	0.2	ns
Total	328 (73%)	121(27%)	449 (100%)		

[a] The P value is denoting the level of significance of difference in the distribution according to gender.

regarding the severity of functional loss (anesthesia, hypesthesia, etc.) was interpreted into accepted medical terms as presented in Table 3. It appears that hypesthesia (n=299; 66.6%) is by far the most prevalent change followed by anesthesia (n=128; 28.5%). Reduced sensory capacity was not reported by 12 patients who suffered from a persistent neurogenic symptom (paresthesia, etc.). Overall subjective ratings of neurosensory function averaged score, 1.1, i.e., severe loss of function was felt by the majority of patients.

Neurosensory loss of function All oral branches of the trigeminal nerve involved were significantly affected by the injury, and details of functional impairment related to specific nerve branches are presented in Table 4. Pain perception was tested in 411 patients and lost in 105 patients (25.5%) as a sign of severe nerve injury. The ability of two-point discrimination ≤20 mm was lost by 181 (42.9%) patients and retained by 241 (57.1%) patients. In patients with retained two-point discrimination ability, the mean threshold value was 10.9 mm (SD 4.5) in the injured side vs 7.6 (SD 3.1) in the healthy side, p<0.0001. The added rating scores of tactile, thermal, and location perception are indicative for the severity of the nerve injury and by this measure, the conductivity of all involved branches of the injured side was badly damaged with a sum score of 10.7 (SD 6.9) vs the healthy side exhibiting a sum score mean of 20.9 (SD 1.3; p<0.0001). The severity of sensory loss as reflected in the sum score mean for females was 10.5 (SD 6.9) and for males was 11.2 (SD 6.9). The small difference of severity expressed in sum score means related to gender of the patient was not statistically significant.

The severity of functional incapacity related to etiology indicates that third molar surgery is not only the most frequent cause of injury (n=319; 71%; Table 2), but it also produces the most severe neurosensory deficiency (Fig. 4).

The neurosensory function related to nerve branch and etiology is shown in Table 5. It appears that lesions produced by third molar surgery and dentoalveolar surgery were more severe than those associated with the injection of local analgesics. Obviously, implant surgery and endodontics did not produce any lingual nerve injuries.

Neurogenic complaints Paresthesia was clearly the most prevalent neurogenic symptom (n=240; 53.5%) but more incapacitating symptoms such as dysesthesia (n=77; 17.1%) and allodynia (n=20; 4.5%) counted for a lot of suffering (Table 6).

Other symptoms A significant number of lingual nerve injury patients suffered from taste abnormalities, not only a loss of taste but also a persistent and unpleasant taste of metal, old cheese, salt, mold, ammonia, etc. Problems with cooking were frequently related to inability to taste salt.

Difficulty with pronunciation of speech was another frequent problem that may follow the loss of neurosensory input from both the lingual and the inferior alveolar nerve. Increased concentration on pronunciation was necessary and it often presented a stress factor.

Table 2 Etiology of 449 iatrogenic injuries to oral branches of the trigeminal nerve

Nerve branch	Third molar surgery	Injection of local analges.	Dentoalveolar surgery	Implant surgery	Endodontics	Other or unknown	Total (%)
Lingual nerve	196	59	2	0	0	4	261 (58%)
Inf. alveolar nerve	94	15	11	16	10	3	149 (33%)
Buccal nerve	29	1	1	0	0	1	32 (7%)
Mental nerve	0	0	3	0	0	0	3 (1%)
Infraorbital nerve	0	3	0	0	0	0	3 (1%)
Palatine major nerve	0	0	0	0	0	1	1 (<1%)
Total (%)	319 (71%)	78 (17%)	17 (4%)	16 (4%)	10 (2%)	9 (2%)	449 (100%)

Table 3 Subjective neurosensory deficit after iatrogenic injury to 449 oral branches of the trigeminal nerve

Neurosensory deficit	Lingual nerve (*n*)	Inferior alveolar nerve (*n*)	Buccal nerve (*n*)	Mental nerve (*n*)	Infra-orbital nerve (*n*)	Palatine nerve (*n*)	Total, *n* (%)
Anesthesia	92	30	4	1	1	0	128 (28.5)
Hypesthesia	157	111	27	2	1	0	299 (66.6)
Hyperesthesia	3	2	0	0	0	1	5 (1.1)
Combinations	1	3	1	0	0	0	5 (1.1)
None	8	3	0	0	1	0	12 (2.7)
Total	261	149	32	3	3	1	449 (100.0)
Subjective rating, mean (SD)	1.0 (0.87)	1.2 (0.82)	2.3 (0.67)	–	–	–	

Definition of terms [36]:
[a] Anesthesia—insensitivity to all forms of stimulation
[b] Hypesthesia—diminished sensitivity to all forms of stimulation
[c] Hyperesthesia—increased sensitivity to all forms of stimulation

Discussion

The neurosensory examination

The neurosensory examination applied in this study is simple, and does not require sophisticated equipment, yet, it renders fairly dependable ratings. The test and the communication between examiner and patient are held within simple concepts, ability to perceive stimuli of easily recognizable nature, and side differences. The clinical assessment of severity is from a methodological point of view greatly promoted by comparison with the contralateral, unaffected nerve rather than threshold values that require much more sophisticated measuring technology [37].

The sensory experience is determined initially by the signal pattern generated at the periphery and subsequently by the changes induced in the pattern during its transmission on its way to the cortex [36]. Variables at the periphery affecting these processes are, among several, the nature and the site of stimulation and the density of sensory receptors. Cortical factors contributing to processes of analysis and synthesis are: (1) fluctuations in the attention and concentration of the individual, and (2) the state of the memory patterns and the quality of recall at the moment when the incoming pattern (stimulus) is being matched for identification [36]. Consistent ratings, therefore, demand that the patient is confident with the examiner and that he or she concentrates on the neurosensory test in compliance with the aim of the examination.

The neurosensory impairment may follow a patchy distribution over the cutaneous or mucosal surface innervated by the injured nerve branch yielding spots of

Table 4 Time course from injury to initial examination and neurosensory function[a] at initial examination of 442[b] oral branches of the trigeminal nerve after iatrogenic injury

	Lingual nerve (*n*=261; F/M ratio 180/81)		Inferior alv. nerve (*n*=149; F/M ratio 116/33)		Buccal nerve, intra oral distribution (*n*=32; F/M ratio 27/5)		Buccal nerve, extra oral distribution (*n*=32; F/M ratio 27/5)	
Injury examination [median (range); in months]	7 (0–193)		12 (0–430)		12 (4–50)			
Side	Injured	Healthy	Injured	Healthy	Injured	Healthy	Injured	Healthy
Pain perception (%)	67	100	89	100	64	100	89	100
No pain perception (%)	33	0	11	0	36	0	11	0
2-Point discrimination								
>20 mm	52%	1%	25%	1%	54%	13%	7%	0%
≤ 20 mm	48%	99%	75%	99%	46%	87%	93%	100%
Mean (SD) (≤ 20 mm)	9.2 (4.3)	6.1 (6.2)	10.9 (4.5)	7.6 (3.1)	17.2 (3.4)	10.4 (5.2)	14.0 (3.7)	12.1 (3.5)
Sum score of tactile, thermal, and location perception [mean (SD)]	9.0 (7.2)	20.9 (1.3)	13.4 (5.5)	20.8 (1.5)	10.4 (6.1)	20.8 (0.8)	15.8 (3.7)	21.0 (0.0)

[a] Neurosensory function is expressed with the sum of score ratings (sum score) from a test of the perception of seven tactile, thermal, and location stimuli (range 0–21).
[b] Data from mental, infraorbital, and palatine major branches are left out due to low numbers (*n*=7).

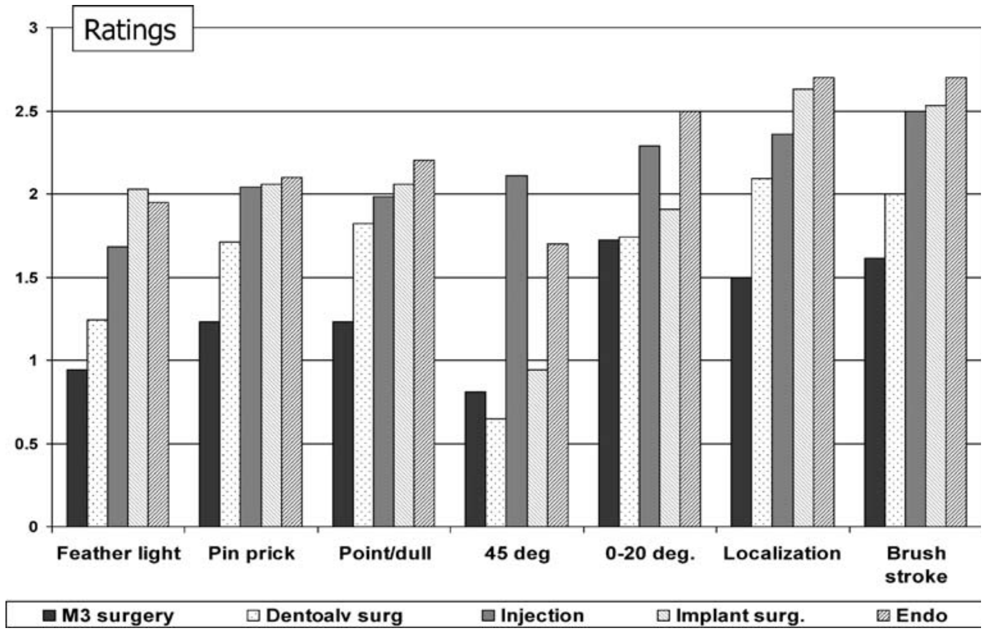

Fig. 4 Neurosensory deficit of tactile, thermal, and location sense of oral branches of the trigeminal nerve related to etiology

anesthesia and other areas with retained sensitivity which may render some inaccuracy of rating. This problem is hardly overcome with more sophisticated test methods [40], but the examiner may take an overview of the situation and rate accordingly.

The discrimination between score 0 (no perception) and score 1 (perception of touch without ability to discriminate the quality of stimulus) is clear and does not present uncertainty. Score 2 denotes the ability of discrimination of the quality of stimulus less clear than the healthy side. It is a roomy rating that ranges within the concept of “less than normal”. It does, however, distinguish between normal and reduced sensory discrimination and perception. Score 3 (normal) reflects the unaffected or completely recovered sensory function. It should be recognised that the results of sensory testing are relatively crude and do not reflect the subjective perception of abnormality in all details [31]. Conversely, the number of single tests may in concert modulate a differentiation of the severity of the injury.

Table 5 Neurosensory function[a] (sum scores) after iatrogenic injury to oral branches of the trigeminal nerve related to nerve branch and category of etiology[b]

Etiology	Lingual nerve	Inferior alveolar nerve	Buccal nerve
Third molar surgery	7.3	12.6	12.0
Injection	14.2	17.2	14.0
Dentoalveolar surgery	7.0	11.0	9.0
Implant surgery	–	14.3	–
Endodontics	–	15.9	–
Other/unknown	12.1	17,2	15.0
	254	148	9

[a] Neurosensory function is expressed with the sum of score ratings (sum score) from test of the perception of seven tactile, thermal, and location stimuli (range 0–21).

[b] Data from mental, infraorbital, and palatine major branches are left out due to low numbers (n=7).

Incidence

The country of Denmark is unique in the sense that there is a central registration of all complications occurring in dental practice, including nerve injuries of all kinds of etiology. The author had occasion to examine a major proportion of these injuries. The increasing number of referred patients over the years probably reflects an increased awareness of quality of care and an increased intolerance towards complications and side effects. Moreover, institutions and insurance companies are now in function to deal with patients’ complaints on a national scale in DK which means a fine meshed filtration of all reported cases to provide reliable statistics. The contribution of this study is that all patients since 1991 have been subjected to a standardized neurosensory examination to establish the degree of functional impairment and the reported severity of neurogenic symptoms.

Neurosensory examination and documentation of the level of incapacity is necessary for the case handling that may lead to reimbursement of insurance money. Reimbursement in DK is not conditioned by proven malpractice whereby the practitioner has no incentive not to cooperate on actual cases of iatrogenic nerve injury. These factors may account for the increased number of reported injuries rather than a true rise in incidence, or an incidence of greater magnitude than that of other countries.

Table 6 Subjective neurogenic symptoms after iatrogenic injury to oral branches of the trigeminal nerve in 449 patients

Neurosensory symptom	Lingual nerve (*n*)	Inferior alveolar nerve (*n*)	Buccal nerve (*n*)	Mental nerve (*n*)	Infraorbital nerve (*n*)	Palatine nerve (*n*)	Total [*n* (%)]
Paresthesia	139	80	20	0	1	0	240 (53.5%)
Dysesthesia	41	31	4	1	0	0	77 (17.1%)
Allodynia	12	4	3	1	0	0	20 (4.5%)
Other	28	11	3	0	1	1	44 (9.8%)
None	21	16	2	1	1	0	41 (9.1%)
No data	20	7	0	0	0	0	27 (6.0%)
	261	149	32	3	3	1	449 (100%)

Definition of terms [36]
[a] Paresthesia is an unusual, abnormal but not painful, spontaneous or evoked sensation (tingling or pricking).
[b] Dysesthesia is any unpleasant abnormal sensation, either spontaneous or evoked, here used to describe painful paresthesia and burning neurogenic discomfort and pain.
[c] Allodynia—pain due to a stimulus that is not normally painful when applied elsewhere to the body

Gender

As in previous studies [11, 35], there is an overrepresentation of the female gender that is difficult to explain. Perhaps females are more prone to see doctors in general, and thereby more at risk. Conversely, it is interesting that there was no gender-related difference in the severity of impairment of the nerve injuries examined in this study as opposed to the study of Sandstedt and Sörensen [35].

Sensory impairment

The magnitude of neurosensory impairment and the amount of neurogenic malfunctions (paresthesia, dysesthesia, etc.), also documented in several other studies [1, 9, 11, 14, 22] is impressive, and it is beyond any doubt that many patients suffer a severe reduction of their overall quality of life. Incidentally, it turned out that specific functions tested in sequence—(1) tactile perception: (a) feather light touch, (b) pinprick, and (c) sharp/dull discrimination, (2) thermal perception: (d) warm, 45° (e) cold, 0–20°, and (3) location perception: (f) point location and (g) brush stroke direction, uniformly showed more damage to tactile perception than the perception of location (Fig. 4). Likewise the perception of warm appears more vulnerable than the perception of cold ($p<0.0001$).

Loss of neurosensory function or painful triggers in the injured nerves' distribution might lead the patients to a unilateral chewing pattern that frequently entailed a temporomandibular dysfunction problem, pain on chewing, etc.

Risk factors and prevention of injury

Third molar surgery was clearly the dominating etiology behind iatrogenic nerve injuries and a number of studies have dealt with preventive measures [3, 12, 26, 34].

Lingual nerve injury Renton and McGurk [28] analyzed factors that might predict temporary and permanent lingual nerve injury and they found age, depth of application, difficulty of operation, surgeon, and surgical technique to be of significance. The application of an instrument to protect the lingual nerve during third molar surgery has been intensively discussed in the British literature, and consensus is hardly to be obtained [3, 10, 12, 32, 39]. The mode of placement of the instrument may be of decisive importance. The periosteum in the third molar region on the medial aspect of the mandible should remain intact as an anatomic barrier separating the lingual nerve from the field of surgery. This applies to bone removal at the distolingual aspect as well as sectioning of the tooth. If this simple precaution is met, injury with permanent impairment of function is hardly possible. Basically, lingual nerve injury in third molar surgery is avoidable.

Inferior alveolar nerve injury Contrary to lingual nerve injuries, damage to the inferior alveolar nerve may be a calculated risk to be accepted and weighed against the indication for third molar removal. Based on this concept, the justification of prophylactic removal in general has been questioned. Assessment of the likelihood of injury depends to a great extent on the quality of preoperative radiographic examination [34]. Three radiological signs were found to be significantly related to nerve injury: (a) diversion of the inferior alveolar canal, (b) darkening of the third molar root at the site of overprojection, and (c) an interruption of the white line of the mandibular canal [34]. In the presence of one or more radiological signs of warning, the prospect of nerve injury must be discussed with the patient, and surgery may be postponed until the advent of absolute indication. One preventive measure might be coronectomy with intentional root retention as suggested by Pogrel et al. [26].

Implant surgery as cause of inferior alveolar nerve injury is presenting as a significant and, to a large degree, avoidable factor. A meticulous radiological assessment taking any distortion of imaging into account is crucial for safe insertion of implants in the premolar and molar regions of the mandible. A reasonable margin of safety is recommendable.

Dentoalveolar surgery other than third molar surgery may lead to unexpected nerve injuries. Although this kind of lesions is few in numbers, referral to specialists in oral and maxillofacial surgery might reduce the rate of these complications.

Injection injuries are rare considering the number of injections of local analgesics administered. Still, a number of patients suffer an unexpected injury that may be permanent. A recent study on injection injury related to market shares of local analgesics showed a significant overrepresentation of injuries related to the administration of Articaine 4% [19].

Treatment options

Nerve lesions with some remaining function shortly after the injury should be followed up with neurosensory examinations until ratings of scores have reached a ceiling level [17, 30]. Then decision on surgical repair or not may be taken. In patients with nothing left to lose, i.e., persistent, total of subtotal loss of tactile perception, and pain protective reaction, microneurosurgical repair (nerve suture or decompression) may restore considerable nerve conduction.

Appendix

Applied neurological terms in alphabetic order

Ageusia	absence of gustatory perception
Allodynia	pain due to a stimulus that is not normally painful when applied elsewhere to the body
Anesthesia	insensitivity to all forms of stimulation
Analgesia	absence of pain in response to stimulation that should normally be painful
Dysgeusia	distorted gustatory perception
Dysesthesia	any unpleasant abnormal sensation, either spontaneous or evoked, used in this study to describe painful paresthesia and burning neurogenic discomfort and pain
Hypesthesia	diminished sensitivity to all forms of stimulation
Hyperesthesia	increased sensitivity to all forms of stimulation
Paresthesia	unusual, abnormal but not painful, spontaneous or evoked sensations (tingling or pricking sensation)

References

1. Akal ÜK, Sayan NB, Aydogan S, Yaman Z (2000) Evaluation of the neurosensory deficiencies of oral and maxillofacial region following surgery. Int J Oral Maxillofac Surg 29:331–336
2. Bartling R, Freeman K, Kraut RA (1999) The incidence of altered sensation of the mental nerve after mandibular implant placement. J Oral Maxillofac Surg 57:1408–1412
3. Bataineh AB (2001) Sensory nerve impairment following mandibular third molar surgery. J Oral Maxillofac Surg 59:1012–1017
4. Carmichael FA, McGowan DA (1992) Incidence of nerve damage following third molar removal: a West of Scotland Oral Surgery Research Group Study. Br J Oral Maxillofac Surg 30:78–82
5. Chaushu G, Taicher S, Halamish-Shani T, Givol N (2002) Medicolegal aspects of altered sensation following implant placement in the mandible. Int J Oral Maxillofac Implants 17:413–415
6. Cornelius CP, Roser M, Ehrenfeld M (1997) Mikroneurale Wiederherstellung nach iatrogenen Läsionen des N. Lingualis und des N. alveolaris inferior. Kritische Bestandsaufnahme. Mund Kiefer Gesichtschir 1:213–223
7. Dao TT, Mellor A (1998) Sensory disturbances associated with implant surgery. Int J Prosthodont 11:462–469
8. Dodson TB, Kaban LB (1997) Recommendations for management of trigeminal nerve defects based on a critical appraisal of the literature. J Oral Maxillofac Surg 55:1380–1386
9. Fielding AF, Rachiele DP, Frazier G (1997) Lingual nerve paresthesia following third molar surgery. A retrospective clinical study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 84:345–348
10. Gargallo-Albiol J, Buenechea-Imaz R, Gay-Escoda C (2000) Lingual nerve protection during surgical removal of lower third molars. Int J Oral Maxillofac Surg 29:268–271
11. Gerlach KL, Hoffmeister B, Walz C (1989) Dysästhesien und Anästhesien des N. mandibularis nach zahnärztlicher Bahandlung. Dtsch Zahnarztl Z 44:970–972
12. Gomes AC, Vasconcelos BC, de Oliveira e Silva ED, da Silva LC (2005) Lingual nerve damage after mandibular third molar surgery: a randomized clinical trial. J Oral Maxillofac Surg 63:1443–1446
13. Grotz KA, Al-Nawas B, de Aguiar EG, Schulz A, Wagner W (1998) Treatment of injuries to the inferior alveolar nerve after endodontic procedures. Clin Oral Investig 2:73–76
14. Haas DA, Lennon D (1995) A 21 year retrospective study of reports of paresthesia following local anaesthetic administration. J Can Dent Assoc 61:319–330
15. Handschel J, Figgener L, Joos U (2001) Die forensische Bewertung von Verletzungen der Nerven und des Kieferknochens nach Weisheitszahnentfernungen im Blickwinkel der aktuellen Rechtsprechung. Mund Kiefer Gesichtschir 5:44–48
16. Harn SD, Durham TM (1990) Incidence of lingual nerve trauma and postinjection complications in conventional mandibular block anaesthesia. J Am Dent Assoc 121:519–523
17. Hillerup S, Hjørting-Hansen E, Reumert T (1994) Repair of the lingual nerve after iatrogenic injury: a follow-up study of return of sensation and taste. J Oral Maxillofac Surg 52:1028–1031
18. Hillerup S, Jensen R (2001) Iatrogene nerveskader opstået i almen tandlægepraksis. Hyppighed, årsager og symptomer. Tandlaegebladet 105:614–622

19. Hillerup S, Jensen R (2006) Nerve injury caused by mandibular block analgesia. Int J Oral Maxillofac Surg 35:437–443
20. Krafft TC, Hickel R (1994) Clinical investigation into the incidence of direct damage to the lingual nerve caused by local anaesthesia. J Craniomaxillofac Surg 22:294–296
21. Kraut RA, Chahal O (2002) Management of patients with trigeminal nerve injuries after mandibular implant placement. J Am Dent Assoc 133:1351–1354
22. LaBanc JP, Gregg JM (1992) Trigeminal nerve injuries. Basic problems, historical perspectives, early successes, and remaining challenges. In: LaBanc JP, Gregg JM (eds) Oral and maxillofacial surgery clinics of North America. Saunders, Philadelphia, pp 277–283
23. Loescher AR, Smith KG, Robinson PP (2003) Nerve damage and third molar removal. Dent Update 30:375–380
24. Lydiatt DD (2003) Litigation and the lingual nerve. J Oral Maxillofac Surg 61:197–200
25. Mason DA (1988) Lingual nerve damage following lower third molar surgery. Int J Oral Maxillofac Surg 17:290–294
26. Pogrel MA, Lee JS, Muff DF (2004) Coronectomy: a technique to protect the inferior alveolar nerve. J Oral Maxillofac Surg 62: 1447–1452
27. Pogrel MA, Thamby S (2004) Permanent nerve involvement resulting from inferior alveolar nerve blocks. J Am Dent Assoc 131:901–907
28. Renton T, McGurk M (2001) Evaluation of factors predictive of lingual nerve injury in third molar surgery. Br J Oral Maxillofac Surg 39:423–428
29. Robinson PP (1988) Observations on the recovery of sensation following inferior alveolar nerve injuries. Br J Oral Maxillofac Surg 26:177–189
30. Robinson PP, Loescher AR, Smith KG (2000) A prospective, quantitative study on the clinical outcome of lingual nerve repair. Br J Oral Maxillofac Surg 38:255–263
31. Robinson PP, Smith KG (1996) A study of the efficacy of late lingual nerve repair. Br J Oral Maxillofac Surg 34:96–103
32. Robinson PP, Smith KG (1996) Lingual nerve damage during lower third molar removal: a comparison of two surgical methods. Br Dent J 180:456–461
33. Robinson PP, Smith KG, Johnson FP, Coppins DA (1992) Equipment and methods for simple sensory testing. Br J Oral Maxillofac Surg 30:387–389
34. Rood JP, Shehab BAA (1990) The radiological prediction of inferior alveolar nerve injury during third molar surgery. Br J Oral Maxillofac Surg 28:20–25
35. Sandstedt P, Sörensen S (1995) Neurosensory disturbances of the trigeminal nerve: a long-term follow-up of traumatic injuries. J Oral Maxillofac Surg 53:498–505
36. Sunderland S (1991) Nerve injury and sensory function. In: Sunderland S (ed) Nerve injuries and their repair: a critical appraisal. Churchill Livingstone, Edinburgh, pp 305–332
37. Teerijoki-Oksa T, Jääskiläinen SK, Forsell K, Virtanen A, Forsell H (2003) An evaluation of clinical and electrophysiological tests in nerve injury diagnosis after mandibular sagittal split osteotomy. Int J Oral Maxillofac Surg 32:1523
38. Venta I, Lindqvist C, Ylipaavalniemi P (1998) Malpractice claims for permanent nerve injuries related to third molar removals. Acta Odontol Scand 56:193–196
39. Walters H (1995) Reducing lingual nerve damage in third molar surgery: a clinical audit of 1350 cases. Br Dent J 25:140–144
40. Westermark A (1999) On inferior alveolar nerve function after sagittal split osteotomy of the mandible. Thesis, Kongl Carolinska Medico ChirurGiska Institutet, Stockholm, pp 1–49
41. Wismeijer D, van Waas MA, Vermeeren JI, Kalk W (1997) Patients' perception of sensory disturbances of the mental nerve before and after implant surgery: a prospective study of 110 patients. Br J Oral Maxillofac Surg 35:254–259
42. Worthington P (2004) Injury to the inferior alveolar nerve during implant placement: a formula for protection of the patient and clinician. Int J Oral Maxillofac Implants 19:731–734
43. Zuniga JR, Meyer RA, Gregg JM, Miloro M, Davis LF (1998) The accuracy of clinical neurosensory testing for nerve injury diagnosis. J Oral Maxillofac Surg 56:2–8