Persistent Pain and Neurosensory Disturbance After Dental Implant Surgery

Pathophysiology, Etiology, and Diagnosis

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KEYWORDS

• Implant • Neurosensory • Neuropathic • Pain • Nerve injury • Sensation • Etiology • Diagnosis

KEY POINTS

- There are multiple risk factors for the development of persistent postsurgical pain; however, the incidence of neurosensory disturbance after dental implant placement is relatively low.
- Many factors probably contribute to the development of a neurosensory deficit, including variations in implant techniques, the operator's skill, the proximity to the nerve canal, and even the psychological status of patient.
- Some studies suggest that certain patients may be genetically more susceptible to neurosensory changes after nerve injury.
- Identifying the clinical features of chronic pain conditions and neuropathies after implant placement can assist in establishing a differential diagnosis.

INTRODUCTION

All dental structures are innervated by the trigeminal nerve, and common dental procedures can result in injury to one of the many branches of this nerve. These procedures, including the determination of local anesthesia,[1] endodontic procedures (Fig. 1),[2,3] suture placement, soft-tissue manipulation (Fig. 2),[4] and third-molar extractions,[5,6] can cause injury to branches of the trigeminal nerve. The nerve most

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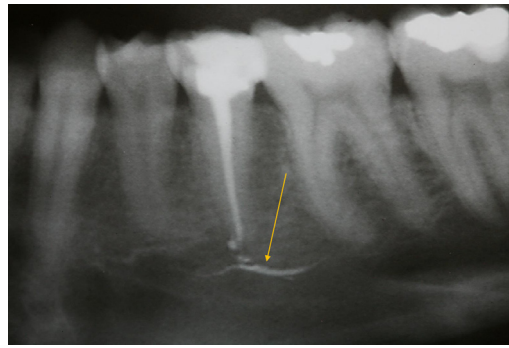

Fig. 1. Arrow in radiograph showing injury to the inferior alveolar nerve after the introduction of endodontic filling into the inferior alveolar canal.

commonly injured during dental procedures is the inferior alveolar nerve (64.4%), followed by the lingual nerve (28.8%).[7] Injuries to these nerves are most often associated with dental anesthesia.

In recent years, the great success of dental implants has led to wide acceptance of such treatment. However, nerve injury and neurosensory impairment can occur after implant placement, even after accurate evaluation and careful treatment (**Fig. 3**).[5] A recent study found that 73% of dentists have reported that their patients have experienced neurosensory impairment after surgical implant procedures.[4]

The published incidence of altered sensation after implant surgery is highly variable, ranging from 8.5% to 36%.[8,9] In addition, published reports vary greatly in the terminology used to describe patients' symptoms after nerve injury. Initially the term paresthesia was used to describe several forms of altered sensation reported by patients, including pain, warmth, cold, burning, numbness, and tingling.

The International Association for the Study of Pain[10] has more clearly defined some of the most common conditions associated with neurosensory alterations (**Table 1**). For example, anesthesia refers to complete loss of sensation; dysesthesia refers to an unpleasant form of altered sensation, such as burning, stinging, or stabbing; paresthesia refers to an altered sensation that is not necessarily unpleasant; allodynia refers to the pain produced by a nonpainful stimulus (light touch); and hyperesthesia is defined as an increased response to a painful stimuli. Although many types of neurosensory changes can occur, persistent pain after implant placement can be

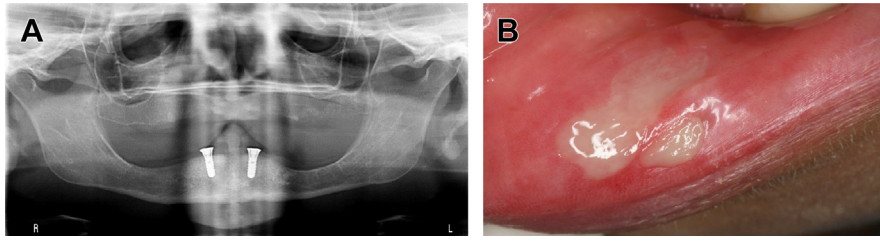

Fig. 2. (*A*) Radiograph showing implant placement with no evidence of injury to the inferior alveolar nerve. (*B*) Clinical presentation of lip biting 1 week after the implant procedure. The patient experienced analgesia attributable to flap manipulation to locate the mental foramina during the implant placement procedure.

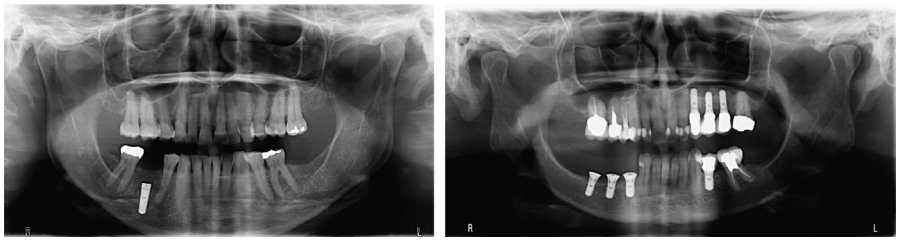

Fig. 3. Radiograph showing injury to the inferior alveolar nerve after implant placement. The implant appears to be completely intruding into the inferior alveolar nerve canal.

neuropathic. Very few data are available regarding the development of chronic persistent neuropathic pain after dental implant surgery.

Injury to a major nerve or a peripheral branch during surgery can result in postsurgical neuropathic pain, some of which can be chronic and persistent.[11] In 1991, Jemt[12] evaluated 2199 implant-supported fixed prostheses in 384 patients, and found that only 3 mandibular implants were removed because of pain within 1 year of placement. With the increasing frequency of dental implant procedures, it is likely that more patients will experience chronic neuropathic pain and altered sensation in the future.

Patients with nerve injury can experience a slight loss or a complete loss of sensation, or even debilitating chronic pain.[4] These symptoms can substantially hinder activities such as eating, drinking, speaking, and socializing, thereby greatly reducing the patient's quality of life.[13] Nerve injury and subsequent altered sensation after implant surgery may result in liability claims.[14,15] Therefore, the clinician must be able to recognize and evaluate factors that can lead to nerve injury associated with implant procedures.

Table 1
Definitions of common neurosensory deficits according to the International Association for the Study of Pain

Term	Definition
Pain	An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage
Allodynia	Pain due to a stimulus that does not normally provoke pain
Analgesia	Absence of pain in response to stimulation that would normally be painful
Dysesthesia	An unpleasant abnormal sensation, whether spontaneous or evoked
Hyperalgesia	Increased pain from a stimulus that normally provokes pain
Hyperesthesia	Increased sensitivity to stimulation, excluding the special senses
Hypoalgesia	Diminished pain in response to a normally painful stimulus
Hypoesthesia	Decreased sensitivity to stimulation, excluding the special senses
Paresthesia	An abnormal sensation, whether spontaneous or evoked
Neuralgia	Pain in the distribution of a nerve or nerves
Neuritis	Inflammation of a nerve or nerves
Neuropathic pain	Pain caused by a lesion or disease of the somatosensory nervous system

Adapted from Merskey H, Bogduk N, editors. Classification of chronic pain, second edition, IASP Task Force on Taxonomy. Seattle (WA): IASP Press; 1994. p. 209–14.

BIOLOGY OF THE NERVE CELLS AND THEIR RESPONSE TO INJURY

The basic structure of the nerve trunk consists of nerve fibers that are collectively organized into fascicles. Each fascicle is surrounded by a layer of loose connective tissue, the perineural layer, which protects the nerve fibers from compressive forces.[16] Each nerve fiber is covered with well-organized tissue, called the endoneurial sheath, which consists of loose connective tissue and blood vessels. The most external surface surrounding the nerve trunk is composed of loose areolar connective tissue and is known as the epineurium.

A typical nerve fiber is composed of a cell body, dendrites, an axon, and axon terminals; this structure is surrounded by a myelin sheath and Schwann cells. The Schwann cells produce myelin, which plays an important role in facilitating nerve conduction. When a nerve fiber is subjected to mechanical injuries, it undergoes a series of structural and biochemical changes. Wallerian degeneration of the tissue distal to the injury begins,[13] and macrophages then infiltrate the site to phagocytose and degrade the debris associated with the damaged myelin sheath and axons.[13,17] Schwann cells proliferate to provide the metabolites needed for the regeneration of the nerve. The original neuron produces new axonal sprouts, which migrate toward the original endoneurial tube, thereby innervating the original tissue.

On occasion, collagen fiber is deposited and scar tissue forms within the endoneurial tube, obstructing the growth of a new axonal sprout and causing intermingling of the new axons.[13] This bundle of new neural tissue is called a neuroma. In addition, the new tissue can grow toward other endoneurial tubes to establish connections and innervate other tissues. In this way certain impulses are transmitted from peripheral nerves to the central nervous system.[17] The degree of complete nerve regeneration depends on the type and extent of the injury; therefore, recovery of sensation cannot always be expected after the nerve-regeneration process.

CLASSIFICATION OF NERVE INJURY

Seddon[18] described 3 types of nerve injury: neurapraxia, axonotmesis, and neurotmesis. Neurapraxia is associated with a temporary blockade of conduction as a result of minor nerve injury. Axonotmesis is a moderate to severe type of nerve injury whereby the basic structure of the nerve tissue is still intact. However, Wallerian degeneration can occur. Neurotmesis is the most severe type of nerve injury, involving complete transection of the nerve that results in permanent nerve injury.

More recently, Sunderland[16] described 5 types of nerve injuries; his classification is based on the anatomic structure of the nerve fibers. A first-degree nerve injury is associated with a temporary conduction block across the fiber without disruption of the anatomy of the axon. With this type of injury, nerve function usually returns to normal.

A second-degree nerve injury is associated with the loss of axon continuity; however, the endoneurial sheath remains intact. Compression or traction may cause transient ischemia, and recovery can be variable. However, regeneration of the axon within the endoneurial tube can occur.

A third-degree nerve injury results from trauma to the neural tissues that disrupts the continuity of the axon and the endoneurium, but leaves fasciculi intact. Regeneration of axons occurs after Wallerian degeneration, which is confined to within the fascicles. An intermingling of the fibers into other endoneurial tubes can occur if the endoneurial tube is occluded by scar tissue that may continue to hinder the regeneration of the axon. Complete recovery is usually not possible.

A fourth-degree nerve injury is associated with disruption of the axon, endoneurium, and fasciculi, but leaves loose connective tissue surrounding the nerve trunk.

Regeneration of the axon is prevented by the development of fibrous scar tissue. Second-, third-, and fourth-degree nerve injuries are similar to Seddon's axonotmesis, depending on the severity of the nerve injury. A fifth-degree nerve injury, the most severe form, consists of complete loss of nerve trunk continuity and is equivalent to Seddon's neurotmesis.

PATHOPHYSIOLOGY OF CHRONIC PAIN

The most common symptom reported after a surgical procedure is pain, which can be categorized as inflammatory, nociceptive, or neuropathic.[19] Immediately after a surgical procedure, pain is experienced because of soft-tissue manipulation, active inflammation, and injury to the peripheral tissues.[11,19] This type of inflammatory pain usually subsides as the tissue heals. Nociceptive pain occurs in response to noxious stimulation of sensory receptors by mechanical, thermal, or chemical provocation. Neuropathic pain can occur even in the absence of any noxious stimuli. It is usually associated with disease or a lesion within the nervous system.[19] The pathophysiology of chronic neuropathic pain involves both peripheral and central mechanisms.

Peripheral Mechanisms That Induce Chronic Pain

Several processes contribute to the development of chronic pain, including increased sensitivity, neuroma formation, ectopic impulse generation, and cross-talk between axons.[20] A neuroma is proliferating neural tissue consisting of fibroblasts and Schwann cells.[11] It is very sensitive to certain neurotransmitters such as norepinephrine, which can evoke spontaneous nerve impulses. This ectopic spontaneous firing sends a nociceptive input into the central nervous system, and this input can be interpreted as an abnormal pain sensation. The response of the nerve tissue depends on the severity of the nerve trauma. Neuroma formation has been associated with puncture, laceration, and stretch injuries to the nerves.[21] Published studies have reported an association between neuropathic complications of the implant procedures and neuroma formation.[11,21] Thus, neuroma formation is suggested to be one of the pathophysiologic features of neuropathic pain.[11,20]

The hallmark of the neuropathic pain is the sensation of pain in the absence of any stimulus. After peripheral nerve injuries, ectopic impulses are generated at various sites, including neuromas and the cell body of the injured neuron.[19] An increase in the number of postsynaptic neurotransmitter receptors after deafferentation of the injured nerve could result in this spontaneous impulse activity.[11] The ephaptic transmission is associated with the development of cross-talk between newly formed fibers or a neuroma and adjacent nerve axons. This activity involves the exchange of impulses between axons and a neuroma that can impose on the central nervous system.[11]

Central Mechanisms That Induce Neuropathic Pain

Changes in the processing of neural impulses in the brain and brainstem can contribute to the development of chronic pain. Continuous neuropathic pain may arise as a direct consequence of a lesion or disease affecting the somatosensory system.[22] Nerve injury can produce ongoing sensitization of central neurons, leading to persistent pain.[23] An injured peripheral nerve can initiate a cascade of neurochemical changes at the site of the injury and in the dorsal horn, or, in the case of the trigeminal nerve, in the spinal tract nucleus. These changes may lead to a reduction in the pain thresholds of afferent nerve terminals in the region of the injury, resulting in primary hyperalgesia.[11] At this point, the patient may begin to report spreading of the pain (expansion of the receptive field).

Central neurons respond to the nociceptive input by altering their function. These neurons begin to respond more quickly to the incoming stimulus, a condition known as central sensitization.[20] Central sensitization also leads to a phenomenon by which even non-nociceptive input carried by A-β fibers (ie, proprioception) is now perceived as painful, so that even light touch to the implant causes pain. The term used to describe this condition is allodynia. Once the dorsal horn cells have become sensitized, the entire processing of nociception can be altered. These changes can be long-lasting or even permanent. In such cases, pain continues even without further nociceptive input. In other words, the tooth or implant continues to be painful even though there is no local cause. The pain now becomes a centrally mediated neuropathic pain that can no longer be managed successfully by manipulating the peripheral tissues. When this condition occurs, pain is no longer the symptom of a disease; it actually is the disease. Genetic polymorphisms, gender, and age may be risk factors that influence whether a particular patient experiences persistent neuropathic pain.[19]

INCIDENCE OF NEUROSENSORY DEFICITS AFTER DENTAL IMPLANT SURGERY

According to several published studies, the incidence of altered sensation after surgical implant placement ranges from 8.5% to 36%.[8,9,11,24] This wide variability may be attributed to a variety of factors: variability in the techniques of implant placement, surgical skills, proximity of the nerve canal, variation in the psychological status of patient, and lack of documentation in evaluating neurosensory function.

Kiyak and colleagues[25] performed a study involving 39 patients who had undergone implant surgery; the investigators used questionnaires to assess patients' psychological response during treatment. Of the 27 patients who completed the study, 43.5% experienced facial paresthesia within 2 weeks after implant placement. Only 4.3% of these patients were expected to have some kind of sensory disturbance. Psychological assessment suggested that high levels of neuroticism or emotional stress may contribute to patient dissatisfaction; these factors should be considered during patient selection.

Astrand and colleagues[26] reported that 18 (39%) of 69 patients receiving dental implants experienced some sensory disturbances within 4 weeks after implant placement. One patient reported complete anesthesia. After 2 years, 9 patients continued to report some sensory disturbance, but the other 9 experienced complete recovery. The investigators concluded that most sensory disturbances resolve within 2 years.

Two prospective multicenter studies reported that paresthesia of the lips after implant placement occurred in 16 (10%) of 159 patients[27] and 19 of (7%) 133 patients.[28] Ten of the 16 and 16 of the 19 patients recovered completely from the paresthesia within 6 months to 1 year. Together, these 2 studies found that 3% of patients continued to have sensory alterations 2 years after implant placement. Other studies have reported persistent paresthesia of the lower lip that continued for more than 3 years in approximately 4% of cases.[29,30]

Ellies and Hawker[8] studied the incidence of altered sensation after dental implant procedures by using a retrospective questionnaire, and classified the condition either as a transient neurosensory deficit that resolved or a persistent neurosensory deficit that continued for more than 6 months after the procedure. Thirty-one patients (36%) experienced altered sensation after mandibular implant procedures and 11 patients (11%) reported persistent changes with no signs of resolution.[8] Patients reported the onset of altered sensation immediately following the procedure, and 90% of the patients with transient altered sensation experienced recovery within 6 months. Daily activities such as speaking, drinking, and eating were most frequently

affected. The lip and chin were the most commonly affected orofacial sites. The incidence of persistent changes (11%) is higher than that reported by other studies. The reasons for this higher percentage may be the retrospective design of the study and the use of a questionnaire, which can introduce recall bias. Furthermore, the chronicity of persistent changes was ambiguously defined in this study. Hence, the incidence of altered sensation reported should be considered with caution.

A randomized controlled clinical trial by Wismeijer and colleagues[31] involved 103 edentulous patients with bone loss who were treated with dental implants. Because severe bone loss required placement of the implants closer than usual to the mental nerve, the study evaluated any alteration in sensation of the lower lip. Eleven of the patients (9.4%) experienced sensory disturbances in the lower the lip within 10 days after the procedure, and 10 patients (10.3%) were still experiencing sensory disturbances 1.5 years after the procedure. It should be noted that 27 of the patients reported some sensory disturbances before implant placement. Therefore, the sensory deficit noted in this study may not have been a direct consequence of the implant procedure. The investigators suggested that altered sensation could be attributed either to the close proximity of the implant to the mental nerve or to pressure caused by ill-fitting over dentures. It is important to interpret these findings with caution, because persistent changes included not only spontaneous neurosensory deficits caused by implant placement but also those possibly caused by the prosthesis.

Bartling and colleagues[9] studied the incidence of altered sensation in 94 patients after placement of mandibular dental implants. According to the treatment plan, the implants were to be located 2 mm above the inferior alveolar nerve canal, as determined by panoramic images, and 1 mm above the canal, as determined by computed tomography (CT) images. Based on these criteria, there was no radiographic evidence of nerve injury. The investigators found that 8.5% of the patients reported altered nerve sensation at their first visit after the placement of the implant. All subjects reported complete resolution of symptoms within 4 months (121 days). One subject reported complete anesthesia for 2 months but a return to normal sensation after that time. The results of this study suggest that injuries to the small intraosseous branches of the trigeminal nerve are less associated with persistent neuropathic disorders.

DIAGNOSIS

A diagnosis of persistent chronic pain is made after the exclusion of all other pathoses that may provoke pain in the affected area. Patient history, gender, age, medical status, dental history, diagnostic imaging studies, and clinical examination should be assessed for a diagnosis of chronic pain. The patient history provides the temporal relationship between injury, normal healing, and persistent pain after an adequate healing time.

When pain continues beyond the normal healing time, the clinician must rule out all potential local causative factors, such as infection or peri-implantitis (**Fig. 4**). When such conditions have been ruled out, a diagnosis of persistent neuropathic pain should be considered. A helpful clinical diagnostic method is neurosensory testing, which includes mapping of the area involved in paresthesia or pain (**Fig. 5**), discriminating between dull and sharp probes, and assessing for allodynia.[32] Validated questionnaires have been used in clinical settings to screen patients with chronic pain and neuropathies; such questionnaires may be an effective tool for diagnosing neuropathic pain.[33] These questionnaires use the clinical characteristics of the pain to distinguish neuropathic pain from other pain disorders, and have been demonstrated to have good validity.

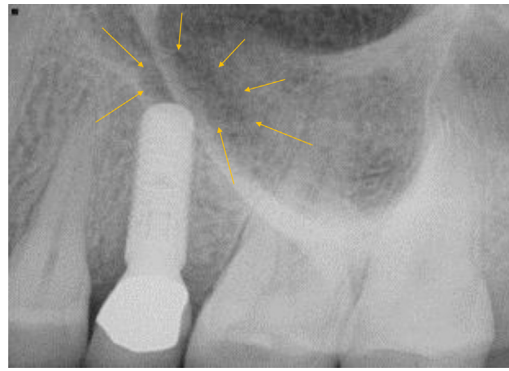

Fig. 4. Radiograph showing dormant long-standing infection around the apex of the implant (*arrows*) causing persistent pain.

Identifying the clinical features of chronic pain conditions and neuropathies after implant placement can assist in establishing a differential diagnosis. The development of paresthesia or anesthesia immediately after or soon after implant placement is a common characteristic of suspected nerve injury. Allodynia, hyperalgesia, or dysesthesia usually has a later onset. Renton and colleagues,[34] Gregg,[21] and Kraut and colleagues[35] have reported the late manifestations of allodynia, hyperalgesia, and dysesthesia in patients with nerve injuries after implant placement.

RISK FACTORS

A substantial proportion of persistent postsurgical pain is very likely to be neuropathic in origin.[36–38] Factors such as preoperative pain, concomitant pain conditions, and impairment in general physical functioning have been associated with persistent postsurgical pain.[39–42] Psychological factors such as anxiety and depression,[39] fear of surgery,[41,42] psychic vulnerability,[43] and catastrophizing[44] have also been reported as risk factors associated with the development of postsurgical chronic pain. In addition, social and economic factors have been associated with an increased likelihood of chronic pain.[37] Genetic risk factors for developing neuropathic pain in humans have been proposed.[19,45,46]

Several studies have reported that women are more likely than men to experience altered sensation and chronic pain.[8,37,47] According to the available case reports in

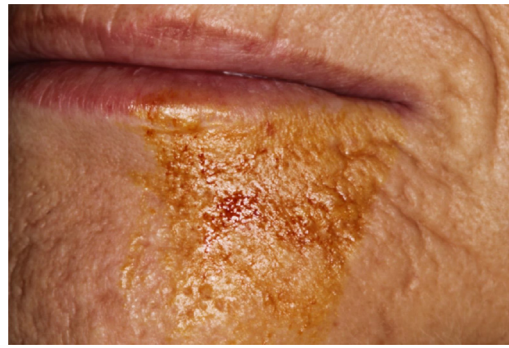

Fig. 5. Clinical presentation of mapped neuropathic area of the lower lip 1 week after injury to the inferior alveolar nerve during implant placement.

the literature, most patients who experienced a neurosensory deficit after implant placement were women older than 40 years.

Risk factors associated with the development of neuropathic pain include age greater than 40 years, smaller-sized mandibles, and bone resorption in response to hormone changes.[26] Gregg[21] reported that chronic neuropathic pain after implant placement is more prevalent in older patients who smoke. Other associated risk factors are resorbed ridges,[31] smoking,[21] and medical conditions such as diabetic polyneuropathies[48] and multiple sclerosis.[49] Patients who engage in activities such as reading, yoga, meditation, and exercise seem to deal better with neurosensory deficits, and young patients show greater improvement than older counterparts.[50]

It is interesting that in one study more than 70% of the patients who reported pain within 6 months after implant placement were not specifically warned of the potential for nerve injury.[51] This finding suggests a relationship between lack of informed consent and continued pain after implant surgery.

SUMMARY

There are multiple risk factors for the development of persistent postsurgical pain. However, the incidence of neurosensory deficits after dental implant placement is relatively low. Many factors probably contribute to the development of a neurosensory deficit, including variations in implant techniques, the operator's skill, the proximity to the nerve canal, and even the psychological status of patient. In addition, some studies suggest that certain patients may be genetically more susceptible to neurosensory changes after nerve injury.[52,53]

It is also important to realize that published studies of neurosensory deficits have not always separated painful conditions from nonpainful alterations. Although all neurosensory deficits have a negative impact on the patient, persistent neuropathic pain disorders are likely to have the greatest effect on quality of life. The dentist must focus on these conditions and determine how to minimize these adverse consequences.

Clinicians who perform implant surgery must be aware of these risk factors, and must consider each of them when making clinical decisions for their patients. Patients should also be informed of these risk factors so that they can actively participate in treatment selection. Further investigations are necessary not only to better understand the relationship between dental implant procedures and neurosensory deficits but also to better understand how to prevent these adverse consequences.

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