# Sensory Changes Related to Dental Implant Placement: A Scoping Review

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**Aims:** To perform a scoping review of the literature to elucidate the occurrence of nerve damage related to dental implant placement and the factors causing the sensory changes. **Methods:** An extensive electronic search was conducted using the Cochrane Library, Medline via Ovid, PubMed, Wiley Online, Science Direct, CINAHL, and the Google Scholar databases from the year 1950 to 2020. **Results:** The search resulted in 1,067 articles, out of which 76 were selected for this review. The articles were categorized as literature review articles, retrospective studies, prospective studies, and case series/case reports. Altogether, 2,526 subjects were assessed retrospectively, with 5.27% transient and 1.39% persistent sensory changes, and a cohort of 2,750 subjects were followed prospectively, with 6.22% transient and 1.31% persistent sensory changes. A total of 336 subjects were enrolled in various case reports and case series, with 5.95% transient sensory changes and 84.52% persistent neurosensory changes. The articles included were not of high quality and have variations in their study designs and reporting procedures, with limited sensory change data to include in this study. **Conclusion:** After surgical placement of dental implants in 5,612 patients, the incidence of transient sensory changes was 5.63%, and the incidence of persistent sensory changes was 6.33%. Factors affecting the incidence were: mandibular location of the implant, with the inferior alveolar nerve as the most commonly affected nerve. The common symptoms reported were paresthesia and dysesthesia. Age and gender were among other factors, for which data were not available in all the articles. *J Oral Facial Pain Headache 2022;36:165–186. doi: 10.11607/ofph.3027*

**Keywords:** *dental implants, sensory changes, transient and permanent, trigeminal neuropathy*

Dental implants have become a common mode of treatment for the replacement of missing dentition.[1,2] Though the clinical restorative success rate is very good,[3] the neurologic complications associated with dental implant placement have not been clearly described in the literature.[4] Goodacre et al[5] performed a systematic review analysis with 217 articles from 1981 to 2001. After collecting clinical data on the success and failure rates of dental implants and listing the associated complications, the review concluded that, among the most acute complications associated with the surgical placement of dental implants, neurosensory disturbances rated as high as 39% and as low as 0.6%, with a mean of 6.1% after one-stage implant surgery.[6] Berglundh et al[7] published a systematic review in 2002 including articles with a 5-year follow-up period and found that, in the studies included, the incidence of sensory disturbance was 41%. In 1% to 2% of cases, these disturbances persisted for more than a year after dental implant surgery. In 2008, Greenstein et al[8] detailed the surgical complications while placing dental implants and recommended steps to avoid and manage them. Lamas Pelayo et al[9] performed a Medline search in 2008 for intraoperative complications during dental implant placement and found that nerve damage was the second most common acute complication after hemorrhage, which can become persistent if left untreated. Most of the literature available previously does not delineate between

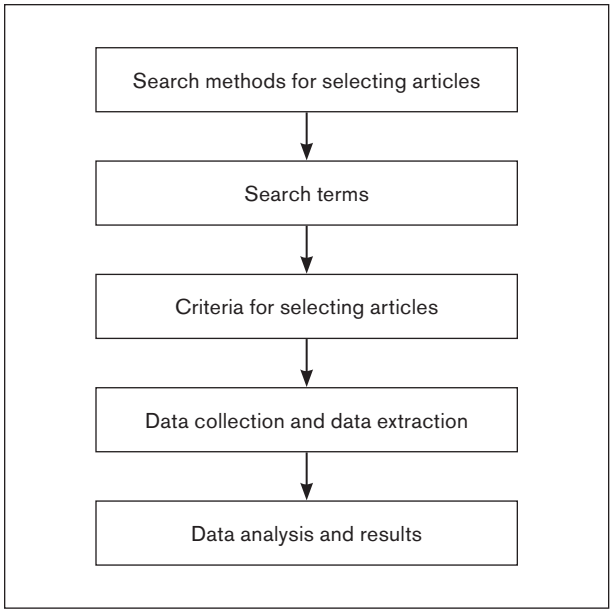


**Fig 1** PRISMA-Scr protocol.

painful and nonpainful transient and persistent sensory changes.[10]

There is a wide discrepancy and inconsistent data on the incidence and characterization of sensory changes and pain caused due to surgical placement of dental implants in the literature.[4] During the surgical placement of dental implants, nerve injury can occur at any stage; ie, while administering the local anesthetic, during or after implant surgery, or during insertion of the implant. Neural damage can either occur due to direct mechanical injury to the nerve (ie, during the osteotomy or implant placement) or indirectly due to the inflammatory response in surrounding tissues following the surgery.[11] Crush-type injuries can occur or compartment syndrome can affect the inferior alveolar nerve due to the nature of the nerve's anatomy.[12] Perineural inflammation along the nerve trunk with no frank axonal damage is sufficient to induce pain in an organ innervated by the affected nerves.[13] Depending on the degree of nerve damage, altered sensations and/or pain can occur.[12] These sensory changes can vary from being transient to permanent. Nonpainful sensory changes may present with signs such as paresthesia and/or anesthesia, whereas painful sensory changes may present with signs such as allodynia and hyperalgesia in addition to the signs of nonpainful sensory changes.[11] The literature reports 4% to 8% incidence of residual long-term neurosensory disturbances, such as inferior alveolar nerve paresthesia.[14,15] In many instances, there is a reduction in these symptoms as time progresses. According to a retrospective review by Goodacre et al,[6] neurosensory impairments reduced from 7% to 1–2% after the elapse of the first year. However, a few other prospective studies[16–18] provide a range from 0% to 13% for the incidence of long-term neurosensory alterations. This wide-ranged discrepancy may be due to numerous factors, including variability in surgical techniques, the type of surgery performed, the proximity to the nerve canal, the psychologic status of the patient, and most important, lack of documentation and skill in evaluating neurosensory function.[19]

This study aims to perform a scoping review of the literature to elucidate the incidence of and factors affecting the transient and persistent sensory changes after dental implant placement in order to map the research done in this area and to identify any existing gaps in knowledge, which will pave the way for future systematic reviews on this topic.[20]

## Materials and Methods

The inclusion criteria were as follows: articles published from 1950 to 2020, with no language restrictions, only human studies, and any study design, including meta-analysis, systematic review, non/randomized clinical trial, cohort, case-control, prospective, retrospective, literature review, case report, and case series.

Although the present study is not a systematic review, the PRISMA-ScR methodology was followed (see checklist Fig 1) to conduct this scoping review.[20,21] A scoping review is a newer approach for gathering evidence and is different from a systematic review. A scoping review is a useful tool to identify research gaps and summarize the qualitative findings of the available research.[22–25] Assessment of risk of bias is required for a systematic review but is not mandatory for a scoping review. A scoping review is less rigorous and can be a prerequisite to doing a systematic review. A scoping review informs us what the gap in knowledge is and whether it is necessary to do a systematic review on the subject.

The use of the present scoping review protocol was attempted in the Cochrane Library; however, its strict guidelines failed to identify any articles. Extensive electronic searches of the Cochrane Library, Medline, PubMed, and Science Direct, Springer link, Wiley online library, CINAHL (Cumulative Index to Nursing and Allied Health Literature), and Google Scholar databases were conducted with no language barrier from the years 1950 to 2020. The Boolean search method was used for the following keywords: dental implants; sensory changes; altered sensations; paresthesia; neurosensory disturbances; neuropathy; and trigeminal neuropathy.

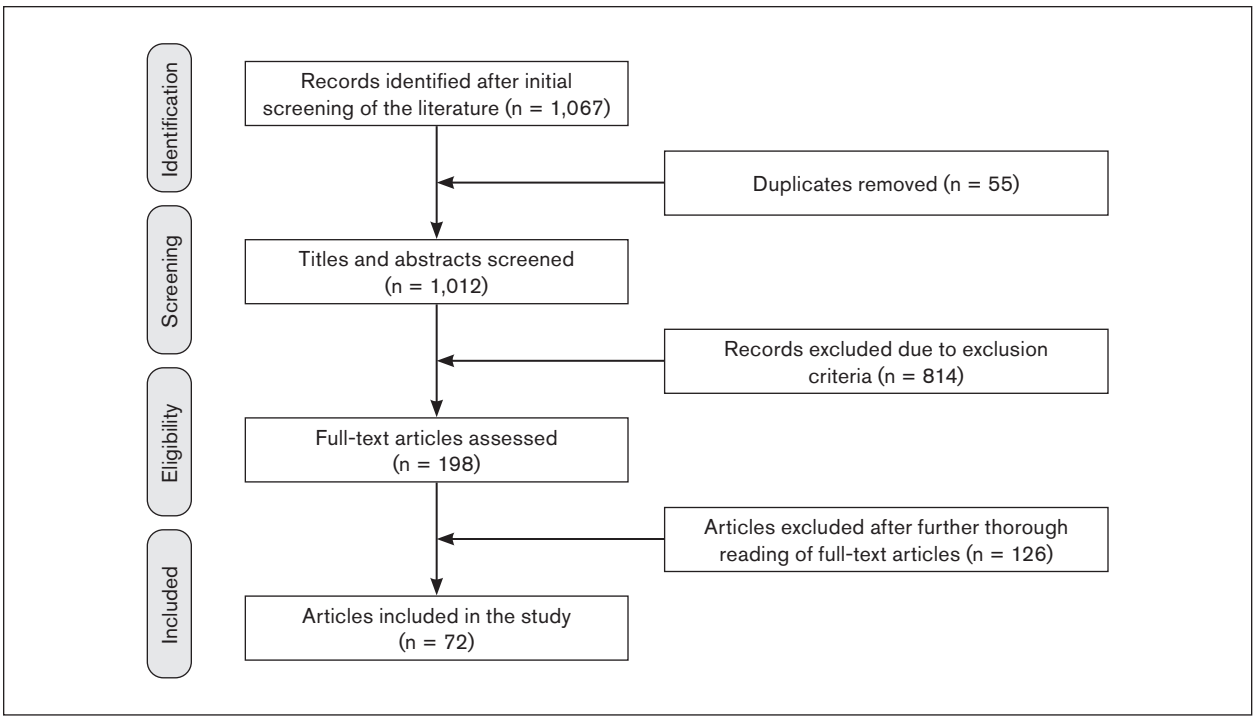


**Fig 2** Flowchart showing study inclusion process.

## Introduction

With the limited and conflicting data available, an attempt was made to perform a critical overview of available publications and research to reach valid conclusions on the incidence of transient (less than 3 months) and persistently altered (3 or more months) sensations following surgical placement of dental implants. This is the cutoff point used in the literature to demarcate the transition between acute and chronic pain,[26] and the authors decided to use the same cutoff point for the demarcation between transient and persistent sensory changes, though a recent meta-analysis reported short-term sensory changes lasting up to 10 days following implant placement, intermediate altered sensations lasting from 3 to 6 months, and persistent sensory changes 1 year after implant placement.[27]

The exclusion criteria were as follows: animal studies, articles reporting neurosensory disturbances following any other invasive surgical procedures, and articles reporting sensory disturbances due to prostheses following dental implant placement. If information was available on chronic pain (3 or more months) after dental implant placement, it was included.

For the data collection process, the preliminary search included literature on any database or internet source with the key terms and without any language restrictions. Research articles, literature reviews, case reports, scientific posters, and published chapters in books, dissertations, and websites were reviewed.

The online searches resulted in: sensory changes with dental implants (29,100 results); dental implant neuropathy (19,900 results); paresthesia with dental implants (7,510 results); pain with dental implants (120,000 results); neurosensory disturbances after dental implant (10,700 results); and trigeminal neuropathy (51,100 results).

An overview of the entire search provided 1,067 articles. Around 55 duplicates were found, and the remaining 1,012 abstracts were screened. Of these, 814 articles were excluded, resulting in 198 articles with abstracts and full texts. After a further thorough reading of the full-text articles, 126 articles were excluded because of lack of exclusivity of transient or persistent sensory changes after dental implant placement in patients. Finally, 72 articles were included in this study. The PRISMA flow diagram was used to obtain the information through the different phases of this scoping review (Fig 2).

The literature review articles reveal that numerous reviews have been performed in the past; however, none provide an accurate report on the incidence of long-term sensory alterations after dental implant placement with predefined inclusion criteria. Therefore, out of the 72 articles included in this scoping review, further categorization was based on the study design: 30 literature reviews (Table 1); 7 retrospective studies (Table 2); 12 prospective

**Table 1 Literature Review Articles**

| Author | Year | Journal | Methods, Results, and Conclusions |
|---|---|---|---|
| Padmanabhan et al[37] | 2020 | *Journal of Indian Prosthodontic Society* | ▪ The aim of this systematic review and meta-analysis was to evaluate the incidence, distribution, and recovery rate of neurosensory disturbance<br>▪ This study concluded that mandibular implant placement is associated with a considerable risk of neurosensory disturbance<br>▪ More randomized controlled trials are required to quantify the effect of factors leading to altered sensation during implant placement. |
| Carter et al[42] | 2016 | *British Dental Journal* | ▪ This article is both a case series and a review of patients presenting with trigeminal neuropathy in eight years to a specialist trigeminal neuropathy dental service.<br>▪ It is highlighted that the majority of these neuropathies are iatrogenic in nature and rarely caused by neoplasia or other medical conditions.<br>▪ Authors found that 68 out of 372 (18.28%) patients had mandibular trigeminal neuropathy due to dental implants. |
| Lin et al[27] | 2016 | *PLoS One* | ▪ This is a meta-analysis of 26 articles published between 1990 to 2016.<br>▪ The meta-analysis revealed that the short-term (ie, 10 days after implant placement) altered sensation was 13% and the long-term (ie, 1 year after implant placement) altered sensation was 3%. |
| Al-Sabbagh et al[19] | 2015 | *Dental Clinics of North America* | ▪ The article lists multiple risk factors for neuropathic pain, reviews literature on the incidence of neurosensory disturbances, and emphasizes that the published studies have not always differentiated between painful and nonpainful disturbances. |
| Jacobs et al[43] | 2014 | *Periodontology 2000* | ▪ The aim was to review neurovascular challenges in the jawbone and potential risks.<br>▪ Articles, case reports, micro- and macro-anatomical studies, and radiographic studies were included. |
| Dannan[44] | 2013 | *The Internet Journal of Dental Science* | ▪ No accurate search criteria for articles listed.<br>▪ Articles with traumatic injury to inferior alveolar nerve after dental implant surgery were only included.<br>▪ Methods that could be used to diagnose sensory deficiency were emphasized.<br>▪ No research question; poor study design. |
| Juodzbalys et al[45] | 2013 | *Clinical Oral Implants Research* | ▪ The purpose was to analyze reasons for nerve injury and propose guidelines for managing inferior alveolar nerve injuries. |
| Renton[46] | 2013 | *British Dental Journal* | ▪ Discusses complications related to all surgical interventions.<br>▪ Suggests managing techniques.<br>▪ Nerve injury/damage was included. |
| Tinastepe and Oral[47] | 2013 | *Ağri* | ▪ Posttraumatic peripheral pain neuropathies are seen after dental treatments are discussed. |
| Greenwood and Corbett[48] | 2012 | Chapter in: *Dental Emergencies* | ▪ Chapter in a book highlighting neurosensory disturbances after implant placement and management. |
| Palma-Carrió et al[49] | 2011 | *Medicina Oral, Patologia Oral, y Cirugia Bucal* | ▪ Only PubMed search engine used.<br>▪ Articles from 2000 to 2010 included.<br>▪ No inclusion/exclusion criteria.<br>▪ Sensory disturbances caused by direct placement of implants included.<br>▪ No graphs, tables.<br>▪ No predefined criteria for complications, as in all were included under sensory changes—eg, postoperative pain, sensory deficits, peri-implantitis, neurogenic pain. |
| Juodzbalys et al[30] | 2011 | *Journal of Oral & Maxillofacial Research* | ▪ Articles from 1972 to 2010.<br>▪ Language limited to English in the search.<br>▪ Keywords limited to inferior alveolar nerve – injuries, paresthesia, repair.<br>▪ The purpose was to review etiologic factors, mechanisms, clinical symptoms, diagnostic methods, and to create guidelines for the management of the inferior alveolar nerve injury during implant placement. |
| Siqueira and Siqueira[50] | 2011 | *Revista Dor* | ▪ The aim was to review dental implant loss, especially related to trigeminal sensory abnormalities, nerve injury, or persistent pain related to implant procedures.<br>▪ Suggested protocol with topics to be investigated during clinical assessment. |
| Sánchez Garcés et al[51] | 2011 | Chapter in: *Implant Dentistry. The Most Promising Discipline of Dentistry* | ▪ Talks about neurosensory impairment as one of the complications of implant dentistry. |
| Kim[52] | 2011 | Chapter in: *Implant Dentistry. A Rapidly Evolving Practice* | ▪ The chapter contains surgical complications associated with dental implant surgery and management.<br>▪ Neurosensory disturbance as one of the complications. |
| Alhassani and AlGhamdi[53] | 2010 | *Journal of Oral Implantology* | ▪ Discusses the cause of inferior alveolar nerve injury and its diagnosis, prevention, and management. |

**Table 1 Literature Review Articles *(continued)***

| Author | Year | Journal | Methods, Results, and Conclusions |
|---|---|---|---|
| Moore and Haas[54] | 2010 | *Dental Clinics of North America* | ▪ Article reviews extend complications like paresthesia and assess the incidence of paresthesia in surgical procedures of dental implants, which were as high as 37%. |
| Renton[55] | 2010 | *Dental Update* | ▪ Reviews the etiology and prevention of IAN injuries in relation to dental procedures. |
| Lamas Pelayo et al[9] | 2008 | *Medicina Oral, Patologia Oral, y Cirugia Bucal* | ▪ The aim was to study the intraoperative complications in implant surgery, carrying out a review of articles appearing in Medline over the last 10 years.<br>▪ Nerve damage was listed as one of the complications. |
| Misch and Wang[56] | 2008 | *Implant Dentistry* | ▪ The aim of this review was to highlight the challenges of treatment plan–related, anatomy-related, and procedure-related surgical complications, as well as to discuss the etiology, management, and treatment options to achieve a satisfactory treatment outcome.<br>▪ Nerve injury was listed as an anatomy-related complication. |
| Greenstein et al[8] | 2008 | *Journal of Periodontology* | ▪ Addresses surgical complications associated with dental implant placement and discusses how to avoid and manage them.<br>▪ Nerve injury as one of the complications that may occur due to intrusion into the inferior alveolar, lingual, or mental nerve.<br>▪ It can also result due to bone compression on the nerve.<br>▪ Describes various symptoms and the clinical test to differentiate them and manage such conditions. |
| Peñarrocha et al[57] | 2007 | *Oral Diseases* | ▪ Conditions leading to trigeminal sensory deficits have been listed along with their etiologies.<br>▪ Dental implantology is one of the causes of trigeminal neuropathy. |
| Greenstein and Tarnow[58] | 2006 | *Journal of Periodontology* | ▪ Articles address position, number, and size of the mental foramen, mental nerve anatomy, and consequences of nerve damage were evaluated for information pertinent to clinicians performing implant dentistry.<br>▪ Guidelines were developed to avoid nerve injury during surgery in the foramina area. |
| Hegedus and Diecidue[59] | 2006 | *International Journal of Oral & Maxillofacial Implants* | ▪ The article reviews different nerve injuries, symptoms, and diagnoses and provides information for clinicians to manage patients with neurosensory disturbances. |
| Worthington[60] | 2004 | *International Journal of Oral Maxillofacial Implants* | ▪ Focuses on problems of nerve damage associated with implant placement in the posterior mandible, as well as the causes and recommendations to help practitioners avoid this complication. |
| Goodacre et al[5] | 2003 | *Journal of Prosthetic Dentistry* | ▪ The article identifies types of complications that have been reported with implants and associated implant prostheses.<br>▪ A Medline and an extensive hand search were performed on English-language publications beginning in 1981 to 2001. The search focused on publications that contained clinical data regarding success/failure/complications;<br>The neurosensory disturbance was found to be 7% (among 2,142 patients, 151 showed the incidence). |
| Mraiwa et al[61] | 2003 | *Clinical Implant Dentistry & Related Research* | ▪ The review was based on scientific evidence on the anatomical, histologic, physiologic, and clinical aspects of the neurovascularization of the anterior mandible.<br>▪ Neurovascular disturbances associated with different nerves, along with the reported incidence, have been reviewed. |
| Gregg[14] | 2000 | *Annals of the Royal Australasian College of Dental Surgeons* | ▪ The review reports a permanent neurosensory disorder of 8% resulting from injuries to the trigeminal nerve.<br>▪ The importance of differentiating between different sensory disturbances is mentioned. |
| Dao and Mellor[12] | 1998 | *International Journal of Prosthodontics* | ▪ Literature review with retrospective studies, patient surveys, and few prospective psychologic studies on sensory disorders following dental implant surgeries. |
| Vallerand[62] | 1992 | *New York State Dental Journal* | ▪ Review of surgical procedures and protocols to avoid, diagnose, and manage nerve injuries. |

**Table 2 Retrospective Research Articles**

| Author | Year | Title | Journal | Study design | Enrolled subjects for dental implant surgeries | Gender/ age |
|---|---|---|---|---|---|---|
| Vázquez-Delgado et al[10] | 2018 | Prevalence of neuropathic pain and sensory alterations after dental implant placement in a university-based oral surgery department: A retrospective cohort study | *Gerodontology* | Retrospective cohort study; clinical files from patients submitted to dental implant placement between February 2004 and September 2014 in the Oral Surgery and Implantology Master degree program of the Faculty of Dentistry of the University of Barcelona (Spain) | 1,156 patients, of which 1,012 met the study inclusion criteria | 417 men (41.2%) and 595 women (58.8%)<br><br>Mean age 60.7 y (16–90 y) |
| Scarano et al[63] | 2017 | Neurosensory disturbance of the inferior alveolar nerve after 3,025 implant placements | *Implant Dentistry* | Retrospective study; patients enrolled between February 2004 and July 2015. | 1,065 patients | No gender prevalence mentioned in the study; mean age 58.9 y |
| Deppe et al[64] | 2015 | Trigeminal nerve injuries after mandibular oral surgery in a university outpatient setting—A retrospective analysis of 1,559 cases | *Clinical Oral Investigation* | Retrospective analysis from January 2000 to December 2009 | 48 patients had dental implant surgery | NA |
| Kütük et al[65] | 2013 | Anterior mandibular zone safe for implants | *Journal of Craniofacial Surgery* | Retrospective clinical study 2007 to 2012 | 55 | 9 women, 1 man |
| Kwon et al[66] | 2004 | The prevalence of sensory disturbance after implant surgery—Retrospective survey of implant practitioners | *Journal of the Korean Association of Oral and Maxillofacial Surgeons* | Retrospective | 47 | NA |
| Ellies and Hawker[17] | 1993 | The prevalence of altered sensation associated with implant surgery | *International Journal of Oral & Maxillofacial Implants* | Retrospective questionnaire analysis | 112 | 64 women, 36 men; mean age 57 y |
| Ellies[16] | 1992 | Altered sensation following mandibular implant surgery: A retrospective study | *Journal of Prosthetic Dentistry* | Retrospective questionnaire study | 226 | NA |

**Table 2 Retrospective Research Articles *(continued)***

| Author | Location | Subjects with altered sensation | Tests performed | Symptoms | Duration of symptoms |
|---|---|---|---|---|---|
| Vázquez-Delgado et al[10] | Maxilla, mandible, and intermental implant placements | 3 patients were diagnosed as having PPTN, which corresponds to a prevalence of 0.3% (95% CI: 0%–0.6%). Additionally, 5 patients (0.5%; 95% CI: 0%–1.07%) presented TNWP. The combined prevalence of both disorders was 0.8% (95% CI: 0.02%–1.3%). | Sensory alterations were assessed according to the Guidelines of the International Taskforce on Somatosensory Testing of the IASP SIG-OFP (IASP): pinprick testing of the affected zone, thermal stimulation, von Frey filaments evaluation, directional discrimination, two-point discrimination, and finally subjective evaluation by the patient. | Patients with the diagnosis of painful PTTN according to diagnostic criteria of the ICHD-3 beta; paresthesias, hypoesthesia | Follow-up appointments lasted until the medical condition resolved or until it was considered stable in time (ie, permanent paraesthesia after a 12- to 14-month follow-up period). |
| Scarano et al[63] | Patients with partial or complete mandibular edentulism were selected to receive dental implants for oral rehabilitation. | Only 23 (2.2%) of the 1,065 patients presented with sensitivity disturbances 1 month after implant placement, and only 2 (0.19%) after 6 months, though a complete recovery was observed in these patients within 13 months. | Sensitivity (thermal, tactile, pain) was evaluated on the first recall, and patients with IAN sensory disturbances were recalled at intervals of 1, 3, and 6 months after implant placement. | Sensitivity disturbances | 10 days after implant surgery and repeated at intervals of 1, 3, and 6 months up to 13 months |
| Deppe et al[64] | Mandibular post-canine region | 2 patients (4.1%); alveolar nerve injuries | Clinical tests performed with 3 months of follow-up | Hypoesthesia<br>Anesthesia | Not significant after a year |
| Kütük et al[65] | Mandibular canine region | 1,019 dental implants were placed | Dental volumetric CT scans; mechano-receptive test to determine neurosensory changes | Tingling, burning in 8 patients (80%); throbbing in 2 patients (20%); continuous pain in all patients: unilateral (90%), bilateral (10%) | 1 mo in 50%; 6 mo in 10%; 24 mo in 10%; continued in 30% |
| Kwon et al[66] | N/A | Inferior alveolar nerve damage was seen in 45%; 21 cases (61%) were found with a sensory disturbance, which recovered in 6 months, except for 2 cases where sensory disturbance persisted | NA | Dysesthesia<br>Anesthesia<br>Hyperesthesia<br>Hypoesthesia | Sensory disturbance recovered in 6 mo, except for 2 cases where sensory disturbance persisted. |
| Ellies and Hawker[17] | Mandible | Altered sensation was reported by 36%, with 23% of them having transient changes and 13% experiencing permanent changes | Restrospective questionnaire | Numbness/ paresthesia was the most common complaint in almost all patients. | 5-year data collected |
| Ellies[16] | Mandible | 37% reported altered sensations, with 28% having transient sensory changes and 8% reporting long-term sensory changes; higher changes were reported in women. | Questionnaire study; 80% responded | NA | 27 (13%) patients experienced altered sensation within 3 mo, and 17 (8%) patients experienced persistent changes more than 3 mo |

IASP = International Association for the Study of Pain; ICHD = International Classification of Headache Disorders; PTTN = painful posttraumatic neuropathy; SIG-OFP = Special Interest Group of Orofacial Pain; TNWP = trigeminal neuropathy without pain.

studies (Table 3); and 23 case reports and case series (Table 4).

### Data Analysis

Variable and poor reporting of data is seen in the diverse group of included articles. Any variability among studies in a review is termed heterogeneity.[28] The considerable variation in results due to inconsistent methodology may be misleading. However, the following were performed:

- Counts and rates calculation of counting the number of symptoms that each individual experienced
- Time-to-event data that analyzes the time until an event occurs
- Quantitative data analysis by data tabulation
- Narrative assessment of results

## Results

The quantitative results of retrospective articles (n = 7) are described in Table 5. Transient sensory changes were symptoms noticed immediately or within a week of implant placement. Persistent sensory changes lasted for more than 3 months. Common characteristics observed in retrospective studies were:

- The most common location of the implant was the posterior mandible (n = 5), followed by the anterior region, from canine to canine (n = 1).
- The nerve most damaged was the inferior alveolar nerve (n = 4), followed by the mandibular incisive nerve (n = 1).
- There was a female sex predominance, although no data were available on the male to female ratio. Age data were also not available.
- The most common symptoms reported were paresthesia and dysesthesia, though the percentage was not available.

Out of the 7 articles, the study design of 3 was questionnaire-type research with yes or no responses or multiple choices, and 2 were clinical tests with subjective and objective evaluations to assess the neurosensory function. The clinical exam included tests to evaluate the detection threshold, detection perception, thermal detection, pinprick, and two-point discrimination. One of them also included radiographic assessment using CT scans.

The quantitative results of prospective articles (n = 13) are described in Table 6. Common characteristics of subjects in the prospective articles were:

- The most common location was the posterior mandible, and the inferior alveolar nerve was the most common nerve damaged. Three articles reported sensory changes after placement of implants in the anterior mandible (138 subjects), with the mandibular incisor nerve being the most commonly damaged.
- The sex and age data of patients who developed neuropathy were not available.
- The most common symptoms reported were paresthesia and hyperesthesia, but the percentages were not available. Additionally, the sensory changes were not listed in all articles.
- The common sites where neuropathy was reported were the inferior lip, gingiva, and chin.

Sensory changes in case reports and case series (n = 20) are reported in Table 7. Common characteristics observed in these 336 patients (8 patients described individually, and 328 described as part of a case series) were:

- The most affected region was the mandibular posterior region. The inferior alveolar nerve (IAN) was the most affected.
- Women (70.83%) were primarily affected, with an age range from 17 to 83 years (mean 58 years).
- The most common symptom was paresthesia (75%).
- Immediate removal of implants within 24 hours led to improvement in symptoms when compared to delay in removal or treatment.

An association was found between pain and number of implants, but the evaluation was only at the 1-week postoperative follow-up. The pain was present but insignificant in a 2-year follow-up study. The study design of the prospective articles included questionnaire-type (n = 5), pain scale (visual analog scale [VAS], n = 1) and clinical examination (neurosensory testing, n = 7). A few articles with questionnaires also had clinical test evaluations as part of their examinations. Therefore, the data of both retrospective and prospective studies were combined to assess the incidence of sensory changes after dental implant placement (Table 8).

## Discussion

There are many articles in the literature related to pain following dental implant placement in patients, but there are very few that specifically mention sensory changes such as paresthesia, hypoesthesia, dysesthesia, numbness, tingling, etc. These sensory changes could be either transient or persistent.[11,19,29]

The present scoping review identified a total of 72 articles, of which 30 were literature reviews, 7 were retrospective, 12 were prospective, and 23 were case reports and case series on sensory changes after dental implant placement in patients. Of the 30 literature reviews, the included articles were on sensory changes related to dental implant placement and on risk factors, complications, and techniques to manage and avoid them.

Iatrogenic mishaps may occur, as with any other surgical procedures. Clinicians should be cautious, and a better understanding of the anatomy of vital structures around implants is necessary. Ultimately, it is prudent not to use specific locations that have high potential risks for nerve injury.

Mastering technical and safety (eg, implant drill stops) procedures for placing implants are important.[30] Pain due to local anesthetic, direct impingement of the implant on the nerves, overdrilling the osteotomy site, and partial or complete nerve transaction are iatrogenic mishaps that can be avoided with drill stops, experience, and training.[31] Moreover, treatment planning with radiographs or cone beam tomograms should be recommended to ensure nerves are completely separated from the dental implant using the smallest field of view necessary so that the radiation exposure is minimal.[32,33] If the mandibular canal cannot be seen on a panoramic radiograph, a cone beam tomogram should be taken to verify its location. However, if such scenarios occur, it was observed that early treatment interventions, either by removal of implant or medications, lead to a better prognosis. Also, most sensory alterations found in this review with the prospective and retrospective articles were reported prior to 2005. Since then, many technologic advancements have been implemented in the field of dental implantology, such as implant placement with the help of computer guidance or augmented reality.[34,35] Hence, iatrogenic failures and nerve damage can be limited.

To manage nerve damage successfully, it is vital to be able to evaluate the extent of nerve damage and the risk factors associated with it as early as possible. Clinicians performing surgical procedures should familiarize themselves with a neurosensory examination that requires no special equipment. Follow-up radiographs and evaluations are mandatory to detect any changes, as early treatment intervention is helpful to resolve neurosensory disturbances after dental implant placement.[30,36]

Timely and early referral to an orofacial pain specialist for noninvasive management is the responsibility of a clinician treating neurosensory trauma cases after implant placement. It is reported that delayed reporting of pain and/or sensory alterations by patients, the poorer the chances for the sensations to return to normal. A better prognosis was observed in a group of patients with early visits to the clinic and with implants placed with a safety margin of at least 2 mm from the IAN.[37,38] The factors that influence the final results are the distance from the implant to the IAN canal and the surgeon's immediate management, such as implant removal, decompression, and medication.[30] These steps ensure the quality of life of the patient is maintained.

In this review, the incidence of transient neurosensory changes was observed in 5.27% and persistent neurosensory changes in 1.39% of the subjects in retrospective studies; moreover, the incidence of transient neurosensory changes was observed in 5.93% and persistent neurosensory changes in 1.31% of the subjects in prospective cohort studies. The incidence of transient neurosensory changes was observed in 5.95% and persistent neurosensory changes in 84.52% of the subjects enrolled in case reports and case series (Table 8). Including the case series and case reports in calculating the incidence could skew the average percentage, as these cases were chosen for publication due to the presence of sensory disturbances after implant surgery, but it was decided to include them in this scoping review, as this information was available in the literature. It is also important to note that, in this scoping review, it was not possible to distinguish between sensory changes related to frank axonal damage and sensory changes following implant placement without evidence of neural damage, and this should be addressed in future studies.

It was found that the mandibular premolar and molar regions were commonly affected areas due to the complex anatomy in this region, which is similar to the findings of Renton et al[39] on common implant positions associated with inferior alveolar nerve injury. In addition, more implants were placed in the mandible than in the maxilla, which is in accordance with the previous literature.[39,40] In this review, women more commonly developed sensory alterations when compared to men, possibly due to various reasons, such as: women visit their health care providers more than men; the prevalence of chronic pain disorders is greater in women than in men; and there could be complex interactions of factors, such as the influence of sex hormones, differences in coping strategies, etc.[39,41]

The present results are based on low-quality research. Most of the research articles included were questionnaire-based and are thus solely dependent on the patients' subjective responses, so the results may not be accurate, especially as patients may be incapable of differentiating and describing the exact symptoms. The report of incidence numbers is based on a diverse group of studies; therefore, the reported

**Table 3 Prospective Research Articles**

| Author | Year | Title | Journal | Study design | Enrolled subjects for dental implant surgeries/implants, n | Gender/age |
|---|---|---|---|---|---|---|
| Hartmann et al[67] | 2017 | Neurophysiological changes associated with implant placement | *Clinical Oral Implants Research* | Prospective with follow-up of 9 y | 33/NA | 17 men, 16 women; median 58 y (28–80 y) |
| Vazquez et al[38] | 2008 | Efficacy of panoramic radiographs in the preoperative planning of posterior mandibular implants: A prospective clinical study of 1,527 consecutively treated patients | *Clinical Oral Implants Research* | Prospective clinical study of 1,527 consecutively treated patients | 1,527/2,584 consecutively placed | 890 women and 637 men; aged from 17 to 86 y (mean age 53 y) |
| Abarca et al[69] | 2006 | Neurosensory disturbances after immediate loading of implants in the anterior mandible: An initial questionnaire approach followed by a psychophysical assessment | *Clinical Oral Investigations* | Prospective study to assess past and present neurosensory disturbances using a questionnaire and a psychophysical approach in patients treated with three immediate loaded implants in edentulous anterior mandible | 65/NA | 30 women, 35 men/30–84 y |
| Kubilius et al[70] | 2004 | Traumatic damage to the inferior alveolar nerve sustained in course of dental implantation. Possibility of prevention | *Stomatologija* | Prospective; tactile and pain sensitivity thresholds determined during first 2 d of implantation, then 7, 14, 28, 45, 60, 90 d, followed by 1 to 2 y | 383/11,152 | 137 women, 246 men |
| El-Sheikh et al[71] | 2003 | Changes in passive tactile sensibility associated with dental implants following their placement | *International Journal of Oral & Maxillofacial Implants* | Prospective study to investigate the changes in passive tactile sensibility for a period of 3 mo following implant surgery | 5/10 (2 each) | 2 women, 3 men/56–78 y |
| Walton[72] | 2000 | Altered sensation associated with implants in the anterior mandible: A prospective study | *Journal of Prosthetic Dentistry* | Prospective study; objective and subjective tests performed before implant surgery and at planned intervals for 12 mo following surgery | 75/NA | 47 women, 28 men/40–87 y |

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**Table 3 Prospective Research Articles *(continued)***

| Author | Location | Subjects with altered sensation | Test(s) performed | Symptoms | Duration of symptoms |
|---|---|---|---|---|---|
| Hartmann et al[67] | Maxilla, mandible | 1 | Mechanical and thermal QST on implant vs control side at chin and lower lip | Abnormal sensory responses to touch coexisting with numbness and temperature algesia | Followed up for 9 y; 1 patient presented late for initial evaluation; loss in MDT and VDT, with a gain in sensitization for pain were experienced by 1 patient for 9 y |
| Vazquez et al[38] | Posterior segment of the completely edentulous mandible | 2 | A panoramic radiograph was the only preoperative imaging technique used to determine the incidence of altered mental nerve sensation after implant placement in the posterior segment of the mandible. | Temporary paresthesia | Lasted 3 and 6 wk; resolved spontaneously |
| Abarca et al[69] | Anterior mandible; all of them treated with 3 immediately loaded implants | 58 completed the questionnaire; 19 (33%) reported neurosensory disturbance after surgery; of these, 11 patients had less than 3 mo of disturbance, and the remaining 8 still complained of neurosensory disturbance | Questionnaire and psychophysical testing: 2-point discrimination test, light touch, thermal sensitivity | Most common sites affected: inferior lip, gingiva, chin<br><br>Symptoms: numbness (9 patients), followed by cutting, beating, itching (2 patients) | Sensory disturbance lasted for 8 and 21 mo for the 8 patients. |
| Kubilius et al[70] | Mandible | 68 (17.755%) suffered from inferior alveolar nerve damage after dental implant placement | Sensographic method used to detect tactile and pain sensitivity thresholds | 38 (9.92%) with mild IAN transient damage had predominant paresthesia; 27 (7.05%) with moderate IAN transient damage exhibited paresthesia; 3 (0.78%) with severe persistent IAN damage experienced hyperesthesia | Follow-up to 45 d postoperation and follow-up to 2 y |
| El-Sheikh et al[71] | Anterior mandible | NA | Measurement of force applied with a custom device | Significant increase in passive tactile sensitivity during 3 mo in subjects treated with immediate loading of implants | Follow-up to 3 mo after surgery |
| Walton[72] | Anterior mandible | 24% reported altered sensation in anterior mandible in the short term; with only 1% reporting changes 1 y after surgery | Objective and subjective tests | Numbness and tingling of lower lip | Follow-up to 12 mo after surgery |

QST = quantitative sensory testing; IAN = inferior alveolar nerve; MDT = mechanical detection threshold; VDT = vibration detection threshold.

**Table 3 Prospective Research Articles *(continued)***

| Author | Year | Title | Journal | Study design | Enrolled subjects for dental implant surgeries/implants, n | Gender/age |
|---|---|---|---|---|---|---|
| Bartling et al[18] | 1999 | The incidence of altered sensation of the mental nerve after mandibular implant placement | *Journal of Oral & Maxillofacial Surgery* | Prospective study to determine the incidence of altered sensation; neurologic testing followed up until 6 mo, or later until the altered sensation resolved after the implant surgery | 94/405 | 43 women, 51 men |
| Wismeijer et al[73] | 1997 | Patients' perception of sensory disturbances of the mental nerve before and after implant surgery: A prospective study of 110 patients | *British Journal of Oral & Maxillofacial Surgery* | Prospective randomized controlled clinical trial: Patient perception of sensation of lower lip before surgery, 10 d later, and 16 mo after implant surgery | 110/NA | 76 women, 34 men; 30–80 y |
| Higuchi et al[15] | 1995 | Implant survival rates in partially edentulous patients: A 3-year prospective multicenter study | *Journal of Oral and Maxillofacial Surgery* | Prospective study | 139/460 | NA/15–80 y |
| Johns et al[74] | 1992 | A multicenter study of overdentures supported by Brånemark implants | *The International Journal of Oral & Maxillofacial Implants* | Prospective study with 9 clinical centers with 1-y follow-up | 133/117 in maxilla, 393 in mandible | 59 women, 74 men/ 32–75 y |
| Kiyak et al[76] | 1990 | The psychological impact of osseointegrated dental implants | *The International Journal of Oral & Maxillofacial Implants* | Prospective longitudinal questionnaire study; assessed before and after until 18 mo after surgery | 39, but a total of 27 completed the study/NA | 79.5% women, 19.5% men; 36–78 y |
| van Steenberge et al[77] | 1990 | The applicability of osseointegrated oral implants in the rehabilitation of partial edentulism: A prospective multicenter study on 558 fixtures | *The International Journal of Oral & Maxillofacial Implants* | Prospective study with 9 clinical centers; with follow-up visits after 1 wk, 1 mo, 6 mo, and 12 mo; patients will be evaluated after 24, 36, 48, and 60 mo following prosthesis placement | 154/558; 68 in maxilla, 91 in mandible (521 completed the study) | NA/15–80 y |

**Table 3 Prospective Research Articles *(continued)***

| Author | Location | Subjects with altered sensation | Test(s) performed | Symptoms | Duration of symptoms |
|---|---|---|---|---|---|
| Bartling et al[18] | Mandible | 8 patients (8.5%) reported altered sensation in the postoperative visit | Subjective assessment and neurologic testing | Paresthesia, anesthesia Most of these patients had a large number of implants placed, but the altered sensations returned to normal in all of them by 121 d following implant placement. | Follow-up to 6 mo after surgery |
| Wismeijer et al[73] | Mandible | Considering a 3-mm safety margin around the mental foramen, the study still showed 7% sensory disturbance in the lower lip | Questionnaire | 26 (25%) had altered sensation of lower lip before surgical procedure; 11 (11%) at 10 d, and 10 (10%) had altered sensation of lower lip 16 mo following surgery | Follow -to 16 mo postsurgery |
| Higuchi et al[15] | Maxilla, mandible | NA | Questionnaire, 80% responded | 4% paresthesia of inferior alveolar nerve was reported | Follow-up to 5 y |
| Johns et al[74] | Maxilla, mandible | NA | Multicenter study involving 9 clinical centers, clinical and radiologic exams | 19 patients suffered from paresthesia after mandibular implant surgery; 16 of these recovered by the time of prosthesis placement | In 1 patient, paresthesia still existed 1 y later. |
| Kiyak et al[76] | NA | 4.3% experienced facial paresthesia at first-stage surgery; later, 43.5% reported experience at second stage, but none reported persistent sensory changes | Questionnaire | Paresthesia | Follow-up to 14–18 mo |
| van Steenberghe et al[77] | Maxilla, mandible | 16 patients complained of transient paresthesia of lower lip; 1 year after prosthesis placement, 6 patients still complained of persistent paresthesia | Clinical exam | Paresthesia of the lower lip | Follow-up to 12 mo; then later to 60 mo after prosthesis placement |

QST = quantitative sensory testing; IAN = inferior alveolar nerve; MDT = mechanical detection threshold; VDT = vibration detection threshold.

**Table 4 Case Reports and Case Series**

| Author | Year | Title | Journal | Enrolled subjects for dental implant surgeries | Gender | Age |
|---|---|---|---|---|---|---|
| Politis et al[40] | 2017 | Report of neuropathic pain after dental implant placement: A case series | *International Journal of Oral & Maxillofacial Implants* | 26 | NA | NA |
| Devine et al[41] | 2016 | Chronic post-surgical pain following the placement of dental implants in the maxilla: A case series | *European Journal of Oral Implantology* | 10 | 9 women, 1 man | Average 55.4 y |
| Du Toit et al[78] | 2015 | Implant injury case series and review of the literature part 1: Inferior alveolar nerve injury | *Journal of Oral Implantology* | 4 | Woman<br>Woman<br>Woman<br>Man | 42 yr<br>33 y<br>27 y<br>43 y |
| Givol et al[79] | 2013 | Inferior alveolar neurosensory deficiency associated with placement of dental implants | *Journal of Periodontology* | 92 | 58 women | 27–89 y |
| Mourào et al[80] | 2013 | Role of homeopathy in post-surgical dental implants paresthesia–A case report | *Journal of Case Studies in Homeopathy* | 1 | Man | 63 y |
| Wright[81] | 2011 | Persistent dysesthesia following dental implant placement: A treatment report of 2 cases | *Implant Dentistry* | 2 | Man<br>Woman | 56 y<br>66 y |
| Stamatin et al[82] | 2011 | Post-implant neurological complications in the horizontal mandibular arch | *International Journal of Medical Dentistry* | 27 | Woman<br>Woman | 54 y<br>44 y |
| Al-Ouf and Salti[83] | 2011 | Post-insertion pain in region of mandibular dental implants: A case report | *Implant Dentistry* | 1 | Woman | 27 y |
| Yoon et al[84] | 2010 | Use of botulinum toxin type A injection for neuropathic pain after trigeminal nerve injury | *Pain Medicine* | 1 | Woman | 62 y |
| Rodriguez-Lozano et al[85] | 2010 | Neuropathic orofacial pain after dental implant placement: Review of the literature and case report | *Oral Surgery, Oral Medicine, Oral Pathology Oral Radiology, & Endodontics* | 1 | Woman | 62 y |
| Leckel et al[86] | 2009 | Neuropathic pain resulting from implant placement: Case report and diagnostic conclusions | *Journal of Oral Rehabilitation* | 1 | Man | 56 y |
| Khawaja and Renton[87] | 2009 | Case studies on implant removal influencing the resolution of inferior alveolar nerve injury | *British Dental Journal* | 4 | Woman<br>Woman<br>Woman<br>Woman | 55 y<br>56 y<br>46 y<br>39 y |
| Liang et al[88] | 2008 | Neurovascular disturbance associated with implant placement in the anterior mandible and its surgical implications: Literature review including report of a case | *Chinese Journal of Dental Research* | 1 | Woman | 61 y |
| Elian et al[89] | 2005 | Unexpected return of sensation following 4.5 years of paresthesia: Case report | *Implant Dentistry* | 1 | Man | 34 y |

**Table 4 Case Reports and Case Series *(continued)***

| Author | Tooth number(s) restored, (number of implants) | Symptoms | Duration post injury | Pain level (0–10 VAS) |
|---|---|---|---|---|
| Politis et al[40] | Mandibles of 18 patients, 6 received regular implants and 2 received a zygomatic implant in the maxilla | 17 developed pain due to implant placement,<br>9 developed pain with unknown cause | 12 mo | NA |
| Devine et al[41] | 6 patients had single implants placed, 4 had multiple implants | Onset of pain was immediate in 9 patients with constant pain | NA | Pain intensity ranged from 2 to 9 (average 5.6) |
| Du Toit et al[78] | 29, 30 (2)<br>29, 30 (2)<br>29, 30 (2)<br>29, 30 (2) | Paresthesia<br>Anesthesia<br>Paresthesia<br>Paresthesia | 8 wk<br>NA<br>3 mo<br>12 mo | NA |
| Givol et al[79] | NA | NA | More than 5 y | Pain level not available |
| Mouràò et al[80] | 18, 24, 25 (3) | Paresthesia | 12 mo | 3 |
| Wright[81] | 14 (1)<br>24 (4) | Dysesthesia<br>Dysesthesia | 28 mo<br>36 mo | 3<br>7 |
| Stamatin et al[82] | 21 (1)<br>21 (1) | Paresthesia<br>Paresthesia | NA | Disappeared after 6 wk<br>Disappeared after 3 wk |
| Al-Ouf and Salti[83] | 19, 20 (2) | Dysesthesia | NA | Implant removal reduced pain |
| Yoon et al[84] | 23, 24, 25, 26 (4) | Dysesthesia, allodynia, paresthesia | 2 mo | NA |
| Rodriguez-Lozano et al[85] | Maxilla (8) | Dysesthesia, allodynia | 8 mo | NA |
| Leckel et al[86] | 19, 20 (2) | Dysesthesia | 17 mo | Pain free after removal of one implant |
| Khawaja and Renton[87] | 30 (2)<br>Mandibular quadrant of partial denture<br>19 (1)<br>Mandibular left and right quadrants for a mandiblar implant partial denture<br>20 (1)<br>29 (1) | Paresthesia of lower lip and chin<br>Paresthesia<br>Paresthesia , mechanical allodynia, dysesthesia<br>Paresthesia, mechanical allodynia<br>Paresthesia of right lower lip | Numbness immediately after surgery until implant was removed 18 h after surgery;<br>one of the implants was removed 24 h postsurgery;<br>implant removed 2 days later;<br>implant removed 4 days later | Decrease in symptoms 3 mo later<br>Decrease in symptoms at 2-mo follow-up<br>No improvement in symptoms at 3-mo follow-up<br>No improvement |
| Liang et al[88] | Mandibular arch (4) | Paresthesia, dysesthesia | NA | NA |
| Elian et al[89] | 19, 20, 29, 30 (4) | Paresthesia | NA | Pain reduced after implant removal |

IAN = inferior alveolar nerve; VAS = visual analog scale.

**Table 4 Case Reports and Case Series *(continued)***

| Author | Year | Title | Journal | Enrolled subjects for dental implant surgeries | Gender | Age |
|---|---|---|---|---|---|---|
| Flanagan[90] | 2002 | Delayed onset of altered sensation following dental implant placement and mental block local anesthesia: A case report | *Implant Dentistry* | 1 | Woman | 45 y |
| Gregg[14] | 2000 | Neuropathic complications of mandibular implant surgery: Review and case presentation | *Annals of the Royal Australasian College of Dental Surgeons* | 2 | Woman<br>Man | 45 y<br>50 y |
| *Kim et al[91] | 2013 | Clinical outcome of conservative treatment of injured inferior alveolar nerve during dental implant placement | *Journal of the Korean Association of Oral and Maxillofacial Surgeons* | 64 | 35 women<br>29 men | NA |
| *Juodzbalys et al[45] | 2013 | Inferior alveolar nerve injury associated with implant surgery | *Clinical Oral Implants Research* | 16 | 8 women<br>8 men | 36–65 y |
| *Renton et al[39] | 2012 | Post-implant neuropathy of the trigeminal nerve. A case series | *British Dental Journal* | 30 | 20 women<br>10 men | 26–80 y |
| *Tay and Zuniga[94] | 2007 | Clinical characteristics of trigeminal nerve injury referrals to a university center | *The International Journal of Oral & Maxillofacial Surgery* | 59 patients included in the study, but only 7 (11%) were related to implant procedures | 5 women,<br>2 men | 17–27 y |
| *Libersa et al[95] | 2007 | Neurosensory disturbances of the inferior alveolar nerve: A retrospective study of complaints in 10 years | *Journal of Oral & Maxillofacial Surgery* | 382 subjects were included, and 12 were related to dental implant placement | Prospective longitudinal questionnaire study; assessed before, after up to 18 mo after surgery | NA |
| *Hillerup[96] | 2007 | Iatrogenic injury to oral branches of the trigeminal nerve: Records of 449 cases | *Clinical Oral Investigations* | 449 | NA | 16–83 y |
| *Chaushu et al[98] | 2002 | Medicolegal aspects of altered sensation following implant placement in the mandible | *The International Journal of Oral & Maxillofacial Implants* | 16 | 12 women,<br>4 men | 28–67 y |

**Table 4 Case Reports and Case Series *(continued)***

| Author | Tooth number(s) restored, (number of implants) | Symptoms | Duration post injury | Pain level (0–10 VAS) |
|---|---|---|---|---|
| Flanagan[90] | 20 (1) | Paresthesia | Pain started 4 mo after surgery | Pain free 17 mo later |
| Gregg[14] | Right mandibular body (2)<br>Mandible | Paresthesia<br>Dysesthesia, mechanical allodynia, hyperalgesia | 3 mo to more than 1 y<br>1 y | NA |
| *Kim et al[91] | Posterior mandible | 6 anesthesia<br>28 hypoesthesia and paresthesia<br>17 hypoesthesia<br>13 dysesthesia | 3 had transient sensory changes, whereas 54 had persistent sensory changes | NA |
| *Juodzbalys et al[45] | Right and left premolar, molar region in the mandible | 5 hyperalgesia<br>11 hypoalgesia | More than 3 mo for 11 subjects | NA |
| *Renton et al[39] | Mandibular second premolar, molar | Paresthesia in 47% of cases; mechanical/,thermal allodynia 30%; anesthesia 40%<br>Functional disabilities: Kissing 54%, speech 46%, eating, drinking, brushing teeth due to pain 30%<br>Recurrent lip biting 23%<br>Dribbling 33%<br>Psychologic problems 30% | NA | NA |
| *Tay and Zuniga[94] | NA | 7 patients had at least one functionality problem; 3 mild sensory impairment; 2 moderate; 2 with no deficit | NA | NA |
| *Libersa et al[95] | IAN | 3 (1%) were transient; 9 (12%) with permanent neurosensory disturbances | NA | NA |
| *Hillerup[96] | Implant surgery, 16 out of 449 iatrogenic injuries (3.6%) included in the study | Paresthesia<br>Allodynia | NA | NA |
| *Chaushu et al[98] | Mandibular: 2 premolar, 1 molar | Lip and chin; all 16 patients had persistent sensory changes | NA | NA |

IAN = inferior alveolar nerve; VAS = visual analog scale.

**Table 5 Retrospective Articles Analysis Results**

| Study | Enrolled subjects for dental implant surgeries, n | Transient sensory changes, n (%) | Persistent sensory changes, n (%) |
|---|---|---|---|
| Vázquez-Delgado et al[10] | 1,012 | 0 (0) | 5 (0.49) |
| Scarano et al[63] | 1,065 | 23 (2.16) | 2 (0.19) |
| Deppe et al[64] | 48 | 2 (4.16) | 0 (0) |
| Kütük et al[65] | 55 | 10 (18.18) | 5 (9.09) |
| Kwon et al[66] | 47 | 21 (44.68) | 2 (4.26) |
| Ellies[16] | 212 | 61 (28.77) | 17 (8.02) |
| Ellies and Hawker[17] | 87 | 16 (18.39) | 4 (4.60) |
| Total | 2,526 | 133 (5.27) | 35 (1.39) |

**Table 6 Prospective Articles Analysis Results**

| Study | Enrolled subjects for dental implant surgeries, n | Transient sensory changes, n (%) | Persistent sensory changes, n (%) |
|---|---|---|---|
| Hartmann et al[67] | 33 | 0 (0) | 1 (3.03) |
| Vazquez et al[38] | 1,527 | 2 (0.13) | 0 (0) |
| Abarca et al[69] | 58 | 11 (18.97) | 8 (13.79) |
| Kubilius et al[70] | 383 | 65 (16.97) | 3 (0.78) |
| El-Sheikh et al[71] | 5 | 5 (100) | 0 (0) |
| Walton[72] | 75 | 18 (24) | 1 (1.33) |
| Bartling et al[18] | 94 | 8 (8.51) | 0 (0) |
| Wismeijer et al[73] | 110 | 11 (10) | 10 (9.09) |
| Higuchi et al[15] | 139 | 6 (4.32) | 6 (4.32) |
| Johns et al[74] | 133 | 19 (14.28) | 1 (0.75) |
| Kiyak et al[76] | 39 | 2 (5.12) | 0 (0) |
| van Steenberghe et al[77] | 154 | 16 (10.39) | 6 (3.90) |
| Total | 2,750 | 163 (5.93) | 36 (1.31) |

**Table 7 Case Series and Case Reports Analysis Results**

| Study | Enrolled subjects for dental implant surgeries, n | Transient sensory changes, n (%) | Persistent sensory changes, n (%) |
|---|---|---|---|
| Politis et al[40] | 26 | 2 (7.69) | 24 (92.30) |
| Devine et al[41] | 10 | 0 (0) | 10 (100) |
| Du Toit et al[78] | 4 | 0 (0) | 4 (100) |
| Givol et al[79] | 92 | 0 (0) | 92 (100) |
| Mouràò et al[80] | 1 | 0 (0) | 1 (100) |
| Wright[81] | 2 | 0 (0) | 2 (100) |
| Stamatin et al[82] | 27 | 2 (7.40) | 0 (0) |
| Al-Ouf and Salti[83] | 1 | 1 (100) | 0 (0) |
| Yoon et al[84] | 1 | 0 (0) | 1 (100) |
| Rodriguez-Lozano et al[85] | 1 | 0 (0) | 1 (100) |
| Leckel et al[86] | 1 | 0 (0) | 1 (100) |
| Khawaja and Renton[87] | 4 | 1 (25) | 3 (75) |
| Liang et al[88] | 1 | 0 (0) | 1 (100) |
| Elian et al[89] | 1 | 0 (0) | 1 (100) |
| Flanagan[90] | 1 | 0 (0) | 1 (100) |
| Gregg[14] | 2 | 0 (0) | 2 (100) |
| Kim et al[91] | 64 | 3 (5.26) | 54 (94.74) |
| Juodzbalys et al[45] | 16 | 5 (31.25) | 11 (68.75) |
| Renton et al[39] | 30 | 3 (10) | 27 (90) |
| Tay and Zuniga[94] | 7 | 0 (0) | 7 (100) |
| Libersa et al[95] | 12 | 3 (25) | 9 (75) |
| Hillerup[96] | 16 | 0 (0) | 16 (100) |
| Chaushu et al[98] | 16 | 0 (0) | 16 (100) |
| Total | 336 | 20 (5.95) | 284 (84.52) |

**Table 8 Sensory Changes in Subjects Due to Implant Placement**

| Study design | Enrolled subjects for dental implant surgeries, n | Transient sensory changes, n (%) | Persistent sensory changes, n (%) |
|---|---|---|---|
| Retrospective | 2,526 | 133 (5.27) | 35 (1.39) |
| Prospective | 2,750 | 163 (5.93) | 36 (1.31) |
| Case reports and case series | 336 | 20 (5.95) | 284 (84.52) |
| Total | 5,612 | 316 (5.63) | 355 (6.33) |

incidence is likely biased in many ways and should be interpreted with caution.

In the prospective research articles, follow-up evaluations with neurosensory testing and clinical examinations were limited, mainly for a week or two. Long-term evaluation is necessary for accurate results. Furthermore, data were not available in most of the studies regarding number of implants placed, gender distribution, or specific symptoms of patients.

As can be seen, there was no standardized methodology used, which illustrates wide heterogeneity. The data for persistent pain were insufficient, and cohort studies examining persistent pain after dental implant placement could not be found.

This scoping review reports the incidence of transient and persistent sensory changes related to dental implant placement. As this review has identified gaps in knowledge, it is hoped that the results may assist in informed decision-making for health care providers (clinicians), researchers, and patients.

## Conclusions

Even though the results are based on research that is not of particularly high quality, this study found that the incidence of transient (less than 3 months) sensory changes after dental implant placement is approximately 5.63%, and the incidence of persistent (more than 3 months) sensory changes after dental implant placement is approximately 6.33%.

Nerve injuries in relation to dental implants are impactful, can be persistent, and are often life-changing for patients. Dental implant treatment is, by nature, an elective procedure, and thus these injuries are avoidable if proper treatment planning is followed and if referral to the respective specialist to manage these injuries is timely. The present authors suggest more prospective controlled trials with surgical control and a long-term follow-up to assess persistent pain and neurosensory testing (preferably quantitative sensory testing) on every visit.

## Key Findings

- The incidence of transient sensory changes after dental implant placement is approximately 5.63%.
- The incidence of persistent sensory changes after dental implant placement is approximately 6.33%.
- These injuries may be avoidable if proper treatment planning is followed and referral to the respective specialist to manage these injuries is timely.

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