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A survey of the opinion and experience of UK dentists: Part 1: The incidence and cause of iatrogenic Trigeminal nerve injuries related to dental implant surgery

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ABSTRACT (232 words)

Background: Dental implant-related iatrogenic Trigeminal nerve (TG) injuries are proportionally increasing with dental implant surgery. This study, which is presented in greater detail over a series of papers, assessed the experience of implant-related TG nerve injuries among UK dentists. Incidence and cause of inferior alveolar nerve (IAN), Mental nerve (MN) and lingual nerve (LN) injuries, together with preoperative assessment and the consent process are presented in this paper.

Methods: A survey was distributed among 405 dentists attending an Association of Dental Implantology (ADI) congress in the UK, of which 187 completed the survey.

Results: Most responding dentists were full-time general practitioners. Implant dentistry training was predominately through industry-organized courses. Eighty dentists encountered implant-related IAN injuries, whilst eight encountered LN injuries. Inaccurate radiological identification of the IAN/MN and their anatomical variations (48%) were seen to be the most frequent cause of TG injuries. Disclosure of the relative risk and benefits of alternative implant treatment strategies as part of the informed consent process was not deemed to be essential by 47 (25%) of the participants.

Conclusion: Inadequate radiological assessment was the most common cause of TG nerve injury. The use of small *field of view* CBCT is therefore recommended when placing implants in the posterior mandible. Implant surgeons should acquire evidence-based skills in the prevention, diagnosis, and management of TG nerve injury as well as specific training on justification and interpretation of CBCT scans.

KEYWORDS: Incidence and cause of inferior alveolar nerve injury; Mental nerve injury; Lingual nerve injury; Dental implants; Consent procedures.

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Trigeminal nerve (TG) injury is a common cause for complaints by patients left with lifelong oro-facial neuropathy following dental treatment.[1-3] TG injuries are characterized by neurosensory disturbances, such as pain, numbness or altered tingling-type sensations (paraesthesia), within the teeth, skin and the mucosa.[4-7] The inferior alveolar nerve (IAN) and mental nerve (MN) and the lingual nerve (LN) are the most commonly damaged nerves during dental implant treatment[6, 8-12] with some studies reporting an incidence rate of up to 40% of nerve damage following implant placement surgery in the mandible related to the depth and the width of the implant bed preparation.[8, 11, 13-20]

Local anesthetic injections also cause TG damage due to mechanical or chemical injury.[8, 20, 24-27] Hemorrhage within the inferior dental canal (IDC) can cause chemical nerve injury (related to the iron content in the hemoglobin directly irritating the nerve tissue), or damage due to direct mechanical pressure and indirect ischaemia.[25, 27-29] TG injury may also be caused by bone graft harvesting,[30] third molar surgery, endodontics, ablative surgery, trauma, thermal stimuli and ischaemia, and orthognathic surgery, or a combination of these etiologies.[3, 4, 8, 11, 27, 31-37]

Iatrogenic TG injuries may result in a neurological deficit ranging from total loss of sensation (anesthesia) to a mild decrease in feeling (mild hypoesthesia), troublesome altered sensation (dysesthesia).[4, 21, 38-41] whereby up to 70% of the affected patients can have pain.[4] These symptoms may be constant, spontaneous or evoked (allodynia is a pain response to a normal stimulus), and interfere significantly with everyday functions such as speech, eating, kissing, amongst many others.[4] Thus, these injuries have a significant negative effect on the patient's self-image, quality of life and significant psychological effects that may include suicidal thoughts due to their pain.[20, 42, 43] The consequences of implant therapy can be devastating for these patients as the treatment results of IAN injuries are also often disappointing.[44]

Adjunctive procedures are also sometimes attempted to avoid implant nerve injury.[45] However, previous studies have indicated that regardless of the surgeon's experience, these high-risk procedures that include bone graft harvesting, posterior alveolar distraction and nerve lateralization, may be more likely to result in

injury themselves.[11, 23, 30, 46-48] The most significant issue with dental implant nerve injuries is that higher standards of planning and care would minimize the chances of nerve injuries from occurring.[49, 50]

A recent study showed an alarming lack of written consent for relatively high-risk elective surgery of implant placement in the mandible.[49] However, an informed consent process based on adequate assessment, diagnosis and treatment planning is crucial particularly in high risk cases.[49, 51-54] The Association of Dental Implantology (ADI) of the United Kingdom (UK), Faculty of General Dental Practitioners (FGDP, UK) as well as other international associations such as the Academy of Osseointegration (AO), International Congress of Oral Implantologists (ICOI), the International Team for Implantology (ITI) and the American Academy of Implant Dentistry (AAID) all regularly publish guidelines[12, 52, 56-58] on implant surgery and minimum requirements for diagnostic elements. It is not clear, however, as to whether every clinician who practices the placement of implants follows these guidelines. Studies into whether patients are consented appropriately with respect to iatrogenic nerve injury related to implant dentistry also need to be carried out.

AIMS AND OBJECTIVES:

This study aimed to specifically explore the opinion and clinical experiences of a cohort of experienced implant dentists on the incidence and cause of TG injury related to implant surgery in the UK.

METHODS:

A questionnaire was designed in accordance with the aims of the study, using online software hosted by Survey Monkey® (surveymonkey.com, London).[59] The questionnaire consisted of 41 questions, which were adapted from a previous study.[25] The questionnaire was piloted to improve the accuracy and clarity of the questions. The dentists who took part in the pilot study did not complete the final version of the survey.

Subjects

All dentists (n=405) attending ADI's national congress on dental implantology were invited to complete the survey. Reminders were issued throughout the congress held between 1-3rd May 2013 to encourage maximum participation. To reduce sampling bias, non-attending members of ADI were also invited to

participate through electronic postings. Finally, members of the British Association of Oral Surgeons (BAOS) were invited to complete the online questionnaire. Within the framework of this survey, a dentist was defined as experienced in implant dentistry if they had any postgraduate training in implant dentistry (e.g. Postgraduate (PG) Diploma), and had placed more than 100 implants in total. Only dentists who placed implants in the posterior mandible (irrespective of their experience level) were admitted to the study. The study closed on 30th May 2013.

Data analyses

Responses were collected using the SurveyMonkey© (surveymonkey.com) software. The system was set to disallow multiple responses per email address, but to allow the participants to re-enter the survey and update their responses at a later date. Data were exported into Excel (Microsoft Version 2011) and/or the "Statistical Package for Social Sciences" (SPSS Version 22; Inc, Chicago, Il, USA) format and analyzed using descriptive and frequency analysis statistics.

RESULTS

General demographics of the responders

187 of 405 dentists (46.2%) responded to the survey. The most frequent age group of the respondents was 40-49 years (n=61), followed by 50-59 years (n=53) and 30-39 years (n=46). 17 were between 60-69 and three were between 70-80 years of age. Most respondents were in full-time *general practice* followed by those in *specialist practice* and *practice limited to implantology.* Oral and Maxillofacial Surgery (the specialty of Oral Surgery (OS) in the UK requires a single dental degree, whereas the separate medical specialty of Oral and Maxillofacial surgery (OMFS), requires both dental and medical degrees) represented the largest group of specialists (n=33 OS and n=4 OMFS). Other specialties included: prosthodontics (n=10), periodontology (n=11), restorative dentistry (n=4), endodontics (n=3).

- Postgraduate training of the participants in implant dentistry:

Whilst the training was dominated by industry-organized courses (42%), 40 (24%) of the 164 respondents had specialty training in an allied discipline (e.g. prosthodontics, periodontology or oral surgery), 43 (26%)

had completed an accredited certificate course, and 77 (47%) had a Postgraduate (PG) Diploma or MSc in implant dentistry.

- The surgical implant experience of the participants:

Total implant experience estimated by the respondents ranged between 164,350 to 288,000 implants, with 62 responders placing up to 50 implants in total annually (Fig. 1). Experience of implant placement within the mandible indicated that 19 placed less than 10 implants per annum on average, followed by 46 who placed up to 25 implants per annum. Between 25-200 mandibular implants were placed by 99 (58%) responders. Seven practitioners reportedly placed between 201-300 mandibular implants. Only one practitioner reported placing more than 500 mandibular implants.

Consent process for implant placement in the posterior mandible

- Determination of treatment needs index and/or complexity of treatment:

59 of the 144 responders (41%) used *SAC classification (ADI Guidelines on Implantology, 2012)*[56] whilst 60 (42%) said they followed *FGDP Guidelines on Training Standards in implant dentistry*[60] to determine if the complexity of a given case fell within their level of clinical competence or experience. Cologne ABC risk assessment scores[55] was used only by three responders. Forty-three (30%) responders did not carry out any risk or complexity assessment before obtaining consent for surgery.

- Consent process:

100 responders used an individualized, case-specific, consent letter, whereas 55 relied on a pro-forma consent form that included a general warning about common complications. 75% of the 187 participants thought it to be essential to disclose the relative risk and benefits of alternative implant treatment strategies as part of the informed consent process.

- Disclosure of possible risks and complications:

A minority included warnings of specific complications only if the safety zone was <4mm (Table 1). The possible adverse effect of TG nerve damage on quality of life, interference with applying make-up, or speaking and kissing were not routinely disclosed to the participants.

Use of Articaine in ID blocks:

93 reported they do not use Articaine in inferior dental blocks (IDB's), whilst 31 did use Articaine in IDB's.

Post-operative measures:

92 (72%) of 128 responders indicated they do *home checks* 6-12 hours after surgery for early identification of IANI. Other measures included closely monitoring and controlling post-op infection after operating in the posterior mandible (58%), removing the implant (38%) and referral for immediate management by an expert/specialist (37%), as soon as IANI is diagnosed. Some dentists indicated that they would decompress the nerve (19.5%) and twenty others (15.6%) would observe and monitor the nerve injury for a few weeks before deciding on any definitive surgical intervention to see if the injury would heal spontaneously.

Trigeminal nerve injuries related to implant surgery in the UK

Respondents' experience of nerve damage:

Most respondents (94% of 128 responses) stated that they did not experience any IANI's (63%) or lingual nerve injuries (LNI) following implant surgery. Forty-three (23%) participants did, however, encounter between 1-5 IANI's compared to seven (4%) who saw 1-5 LNI's associated with implant treatment. No dentists saw more than six LNI's related to implant placement but very small numbers of dentists did encounter between 6-10 or 11-20 implant-related IANI's (n=3 and n=2, respectively). Many of these injuries were of immediate onset (54%). 28% of IANI's and 79% of LNI's were permanent.

Causes of implant-related trigeminal nerve injuries:

Inaccurate radiological identification of the inferior alveolar nerve/mental nerve and their anatomical variations (48%; Fig. 2) were seen to be the most frequent cause of IANI according to 54 responders.

- LA-related IANI:

132 responders did not encounter any LA-related IANI. Respondents' experience of the main predictors of nerve damage related to LA during dental implant surgery is summarized in (Fig. 3). The LA infiltration-only technique was used by 70 responders for implant placement surgery in the posterior mandible, and 49 used it only in selected cases. Articaine was the most frequently cited LA used for infiltration in the posterior mandible, at 69 responders, followed by Lignocaine (46 responders). Although the infiltration-only technique was stated to be always effective by 84 responders, 22 stated that the technique sometimes failed to achieve adequate anesthesia and 9 reported that it was not always very effective.

Symptoms experienced by the IANI patients reported by the respondents are shown in (Fig. 4).

DISCUSSION

The response rate in this survey was average, at 46.2%.This may be due to relatively low number of implants being placed by a relatively small number of dentists in the UK. Most responders were general dental practitioners who were rated to be "experienced", and had received structured implant training.

Incidence of TG injuries

The incidence of dental implant related nerve sensory damage (NSD) has been shown to be as high as 40% in past studies[8, 11, 13-20] although at least one prospective large cohort study has shown that risk of TG injuries can be eliminated with meticulous attention to planning and observing good surgical protocols.[61] Nevertheless, the large variation in the reported incidence of NSD suggests that this serious complication of dental implant surgery has not yet been adequately evaluated and reported.[62]

The results of the current study suggest a lower incidence of NSD related to dental implants than that has been reported in the literature.[8, 11, 13-20] This may be due to majority of the responders being relatively experienced surgeons in implant dentistry. Furthermore, a high percentage of the responders appeared to have some risk management strategies in place to reduce the risk TG injuries. These include allowing a "*safety zone*" of 2-4 mm between the apex of the implant and the nerve and using *shorter implant* lengths of 10mm or less when bone height is restricted. It is also possible that the LA techniques and drugs reportedly used by the participants may have had an influence on the lower incidence of NSD. A shortcoming of this study was that the participants were not specifically questioned whether or not the location and/or number of implants might have been associated with NSD in their experience.

Symptoms experienced by the patients

The NSD reported by the participants in this study are consistent with the literature which shows that TG injury following implant placement is a serious complication that can have a profound negative effect on the well-being, psychological health and quality of life of the patient.[4, 20, 42-44]

Cause of Injury

Inaccurate radiological identification of the IAN/MN (and their anatomical *variations)* was cited as the most frequent cause of IANI in the current study. This is supported by the literature and highlights the important role Cone Beam Computer Tomography (CBCT) could play in reducing the risk of TG damage

thus significant morbidity.[63] In this respect it is important to note that the American Academy of Oral and Maxillofacial Radiology (AAOMR), in their revised evidence-based position statement on the selection criteria for radiology in implant dentistry, recommended that *cross-sectional imaging (CBCT) should be used for the assessment of all dental implant sites*.[64] Another weakness of the current study was that a possible correlation between the use of CBCT and the reported incidence of nerve damage was not investigated. The role of CBCT in this respect should be made a priority of future studies.

Preoperative Risk Assessment

30% dentists admitted that they did not carry out any risk or complexity assessment before obtaining consent for an elective procedure of relatively high risk implant placement surgery in the posterior mandible, despite clear guidelines to the contrary.[52, 55] This finding is consistent with a recent Italian study which concluded that, in just over 50% of the malpractice claims investigated, a large number of surgical errors were responsible for the high proportion of injuries to vital structures such as IAN 32.2% and LN 2.5%.[66] The researchers have reported that in 54.5% of these cases incomplete clinical documentation and preoperative planning were evident. It is particularly striking to note that dental implant related NSD could be fully avoidable[31] since the current evidence suggests that these injuries are commonly caused by surgical errors that are directly associated with insufficient preoperative assessment or planning.[49] Inadequate radiological imaging and/or violation of established protocols and good practice guidelines published by ITI[54], AO[52], ICOI[12], ADI[56], and European Association of Osseointegration (EAO)[65], appear to be responsible for these complications .[10, 22, 31, 53, 64, 68, 69]

Consent

The current study is consistent with the literature in suggesting that risk assessment, treatment planning and the consent processes employed by implant dentist may be short of the best practice guidelines in implant dentistry. This was also shown by Strietzel (2003) who documented generally insufficient patient information, during consent, on the nature of the procedure, its financial considerations or alternatives.[70] The clinician has the responsibility to recommend the best evidence-based treatment that is most appropriate to each individual patient's needs and disclose all possible risks (e.g. in the context of IANI; altered sensation and/or chronic neuropathic pain that may affect their daily functions and quality of life), and the alternative procedures (e.g. bone grafting vs. shorter implants) before proceeding with implant treatment.[14, 49, 51, 71-73] As the failure to

carry out adequate examination and risk assessment and failure to conform to best practice guidelines could invalidate the consent process and lead to malpractice claims, this practice needs to be investigated in future studies and should be made a priority in training of implant dentists.

Radiological assessment of the implant site

Conventional Radiography

Panoramic radiographs are safe and reliable techniques for assessing bone height and space when there is sufficient bone above IAN to allow an adequate margin of safety for implant placement.[61] Bartling *et al*. (1999)[17] recommended that a safety margin wider than 2 mm should be allowed when relying only on a panoramic radiograph. Kuzmanovic *et al*. (2003)[72] showed that 62% of the anatomically identified mental loops were not observed on panoramic radiographs. Similarly, a CBCT study[74] found that it was not safe to use an arbitrary safety margin (of 2-4 mm) and recommended that individual assessments should be made on a *case-by-case basis*. Clearly, clinicians should pay attention to the likely location of vital anatomical structures and their possible variations when selecting and justifying the most appropriate method of diagnostic imaging in the mandible.[75]

Cross Sectional Imaging

Although the respondents believed that *insufficient preoperative assessment and planning* was the most common contributing factor for nerve damage, they used CBCT only infrequently. This may be because a clinically significant benefit of CBCT has not yet been shown definitively and the risks may still be seen to outweigh the benefits.

Currently, there are many clinical situations in which CBCT would be highly desirable or strongly indicated for optimal preoperative implant planning and such practice could help to reduce the risk of collateral damage occurring to adjacent vital structures.[64, 76] Moreover, CBCT data can be of further use in 3D implant navigation surgery as well as in digital workflow for the prosthetic construction. In many cases, this could change the risk/benefit analysis when selecting/justifying the diagnostic imaging method especially if the radiation is reduced further by selecting smaller *field of view* (FOV).[77] On the other hand though, CBCT is still a highly invasive radiological technique and therefore it is recommended only as a *supplementary method* in implant planning by most dental organizations.[12, 52, 54, 56-58, 65, 68, 78]

Nevertheless, the current results and literature support the view that CBCT should be considered as the choice of diagnostic imaging when planning implant treatment in close proximity of the vital structures particularly when there is restricted bone quality or quantity.[64] Additional benefits of CBCT would include; the use of computer-aided design or computer-aided surgical guide manufacturing, using dynamic navigation surgical techniques,[80] determination of the length and width of the implant to be placed,[81-83] and identification of anatomic variations and locating nutrient canals. However, dental practitioners should prescribe CBCT imaging only when they expect that the diagnostic yield will benefit patient care, enhance patient safety or improve clinical outcomes significantly.[64, 78, 86]

CONCLUSION

The outcome of IANI can be devastating for the effected patient. This study fortunately showed relatively low incidences of implant related IAN and LN injury. This may have been due to many of the respondents being experienced who used some risk management strategies and had formal training in implant dentistry at Postgraduate Diploma/MSc level.

Surgeons in this survey predominately believed that nerve damage was caused as a result of inaccurate radiological identification of the IAN & MN. The study also highlighted that risk assessment, treatment planning and the consent processes employed by implant dentists may be short of the best practice guidelines in implant dentistry.

In view of the findings of this study and the accumulating evidence for the use of 3D imaging in implant dentistry, the authors recommend the use of small FOV CBCT when operating in close proximity of vital structures in the mandible in order to accurately localize these structures and to select the optimum implant site and dimensions with an adequate safety margin. When doing so, established diagnostic imaging selection and justification criteria should be carefully considered with special reference to case-based risk/benefit analysis. Further studies are indicated to show a definitive clinical significance for using CBCT in reducing the risk of TG nerve injuries in implant dentistry.

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LEGENDS

Part 1:

Fig. 1: The estimated overall annual implant experience of the participants.

Fig. 2: Responses to the question: "what do you think have caused the IANI in your case(s)?" (n=54)

Fig. 3: Causes of LA-related IANI according to the respondents (n=132).

Fig. 4: Main symptoms of the IANI cases related to implant surgery, seen by the responders.

Table 1: Specific risk warnings disclosed by the participants to their patients prior to obtaining their consent.