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ORIGINAL ARTICLE

Availability of CBCT and iatrogenic alveolar nerve injuries

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Abstract

Objective. To examine whether the rapid increase in the availability of cone-beam computed tomography (CBCT) has changed the number of inferior alveolar nerve (IAN) injuries related to the removal of mandibular third molars in Finland. The hypothesis was that the number of nerve injuries should diminish due to better imaging methods. ***Materials and methods.*** The number of CBCT devices, the annual number of CBCT examinations and the number of permanent IAN injuries occurring between 1997 and 2007 were analyzed. The data was collected from three national registers: the Radiation and Nuclear Safety Authority, the Social Insurance Institution and the Patient Insurance Centre. A detailed analysis was made from the cases of permanent IAN injuries. ***Results.*** The first CBCT device was registered in 2002 and the cumulative number of these devices in 2009 was 22. There was an increase from 555 to 3160 in the number of annual CBCT examinations during the period 2004–2009. The total number of permanent IAN injuries during the years 1997–2007 was 129 and remained stable throughout the period (regression analysis, $p = 0.974$, $r^2 = 0.01$). ***Conclusions.*** Contrary to this hypothesis, the availability of CBCT devices has had no significant influence on the number of IAN injuries related to mandibular third molar removals in Finland. More education should be given to optimize the use of CBCT to cover difficult cases that may give rise to complications.

Key Words: *cone-beam computed tomography, mandibular nerve injuries, molar, third, radiology, surgery*

Introduction

Cone-beam computed tomography (CBCT) is a radiographic imaging method that allows accurate three-dimensional (3D) imaging of hard tissues. Since the late 1990s, CBCT devices have been designed for dentomaxillofacial imaging [1,2] and their availability and use are increasing rapidly. The risk of damage to the inferior alveolar nerve (IAN) increases when the roots of the third molar and the IAN are in direct contact [3,4]. In a recent retrospective study by Libersa et al. [5], impacted mandibular third molar removal was found to be the main cause of IAN sensory deficiency after dental procedures. Panoramic and intra-oral radiographs are the basic images for planning treatment of these teeth. These examinations are sufficient for pre-operative imaging in most cases where there is no overlap between the inferior alveolar canal (IAC) and the mandibular third molar [6]. However, the buccolingual relationship between the IAC and the tooth cannot be evaluated in these two-dimensional (2D) radiographs.

In many studies, CBCT is reported to be a useful pre-operative imaging method prior to the surgical removal of mandibular third molars [7–13]. It is a reliable method in locating the IAC [13] and superior to panoramic images in predicting neurovascular bundle exposure during extraction of impacted mandibular third molars [9]. According to the Sedentexct Provisional Guidelines [14] CBCT may be indicated when conventional radiographs suggest a close relationship between a mandibular third molar and the IAC and when a decision to perform surgical removal of the tooth has been made.

The aim of the present study was to examine whether the rapid increase in the availability of CBCT has resulted in a corresponding national decrease in the number of IAN injuries related to removal of mandibular third molars. We analyzed data from three national registers: the Radiation

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and Nuclear Safety Authority (STUK), the Social Insurance Institution (Kela) and the Patient Insurance Centre (FPIC). Our hypothesis was that the number of nerve injuries should diminish due to better imaging methods.

Materials and methods

The first source, STUK keeps a register of all CBCT devices in Finland and its safety permission is needed for their use. The first device was registered in 2002. The number of new CBCT devices registered at STUK during the years 2002–2009 was collected.

Secondly, Kela reimburses the cost of medical treatment, including radiological examinations. According to national Health Insurance Legislation, reimbursement is paid for medical services obtained from private-sector providers; in the case of CBCT examinations this has been paid since June 1st 2004. A pre-requisite for reimbursement is a referral for the imaging examination by a specialist. The number of all CBCT examinations performed from June 1st 2004 to the end of 2009 according to reimbursements made from Kela's register was collected. The indication for the CBCT examination, e.g. mandibular third molar removal, is not registered by Kela.

Finally, the third register is kept by FPIC, which since 1987 has handled claims for personal injury in medical care. Permanent nerve injury cases related to the removal of third molars are also handled by FPIC, and final decisions related to nerve injury claims are usually given up until 2 years after the injury [15]. The number of permanent IAN injuries related to the removal of mandibular third molars between 1997 and 2007 was based on malpractice claims to FPIC. The classification of the Nordic Medico-Statistical Committee (Nomesco) was utilized when searching the FPIC register for these patient cases. The search code for the removal of a tooth was EBA. This is either a simple extraction or a surgical removal. The code has been used at FPIC from the beginning of 1997, thus we included the years 1997–2009. The cases of mandibular third molar removal were selected manually from the EBA files. The data was collected during the summer of 2010 and only completed cases were included. Since the final decisions relating to nerve injury claims are not given until at least 2 years after the injury [15] and the complaint by the patient has to be made within 3 years after the injury, we may assume that decisions on practically all the IAN injuries that had occurred by 2007 had been issued by summer 2010.

From the FPIC files we also recorded the age and sex of the patient, the side of the mandible (right or left), the method of third molar removal (surgical or not), the dentist's specialty, if any, and pre-operative radiological examinations.

In order to check the overall trend in tooth extractions in Finland, we collected the annual numbers of all extractions of any tooth during the study years from Kela's register. These figures include all reimbursed tooth extractions entered in the register. This data was not limited to third molars, but included all teeth.

Linear regression analysis was used for the statistical analysis. The number of annual nerve injuries was regressed on time lapse (the corresponding years) by using SPSS 17.0 (SPSS Inc, Chicago, IL) software.

This study was carried out with the permission of the Ministry of Social Affairs and Health in Finland, according to which approval by an ethical committee was not required for this retrospective, register-based study not leading to patient intervention.

Results

The number of new CBCT devices and the cumulative number of devices registered by STUK during the years 2002–2009 is presented in Figure 1. During this

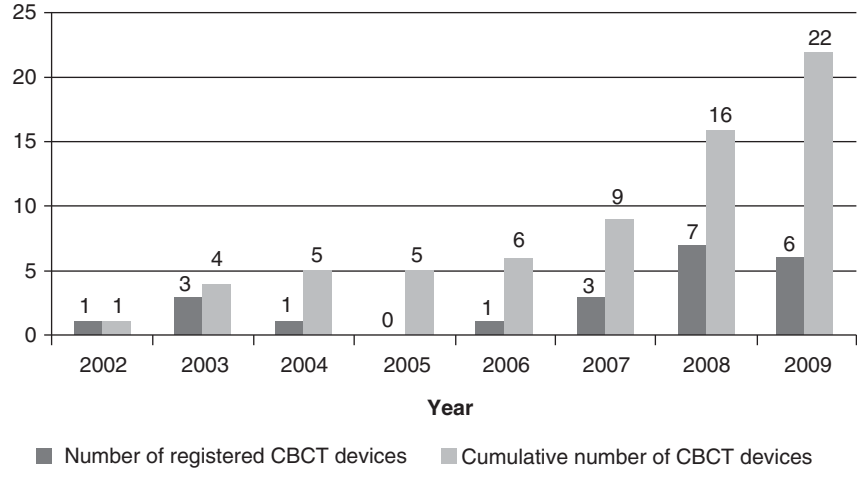

Figure 1. The number of new CBCT devices and cumulative number of devices registered by the Radiation and Nuclear Safety Authority Finland (STUK) during the years 2002–2009.

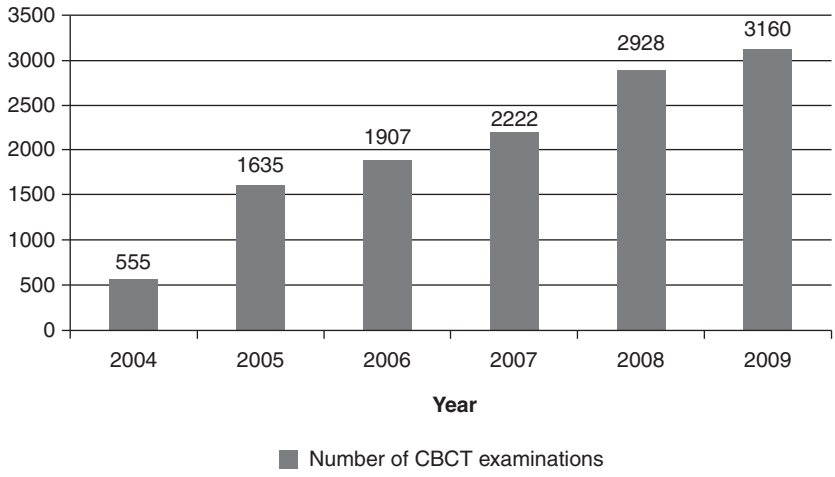

Figure 2. The number of CBCT examinations in Finland during the years 2004–2009. The Social Insurance Institution of Finland (Kela) has reimbursed the cost of these examinations since 2004.

period between one and seven devices were registered annually, the exception being 2005, when no new devices were registered.

The number of annual CBCT examinations performed during years 2004–2009 is presented in Figure 2. There was a more than 5-fold increase in the number of CBCT examinations from 555 in 2004 to 3160 in 2009.

The annual number of permanent IAN injuries related to the removal of mandibular third molars during the years 1997–2007 is presented in Figure 3. The total number of permanent IAN injuries during this period was 129, with a mean annual rate of 11.7. There was no statistically significant association between the annual number of nerve injuries and the time lapse ($p = 0.974$, $r^2 = 0.01$) (Figure 4).

Of the 129 nerve injury patients, 109 (84%) were women. The mean age was 38 years (range 17–78 years). The injury was related to the right mandibular third molar in 63 (49%) of cases. The number of surgical removals was 123 (95%), while the other six (5%) cases were simple extractions. In 48 (37%) cases the extraction was performed by an oral and maxillofacial surgeon, in seven (5%) cases by a specialist in some other dental field, in 73 (57%) cases by a general dental practitioner and in one (1%) case by a graduate student.

In none of the IAN injury cases was a CBCT examination performed pre-operatively. Conventional CT was employed pre-operatively in two cases. In 125 (97%) cases pre-operative panoramic radiographs were taken and in one case a panoramic radiograph was taken during the operation. In three (2%) cases pre-operative intra-oral radiographs were taken and in one case no pre-operative radiographs were taken at all. Besides the panoramic radiograph, in five (4%) cases additional tomographic examinations were done pre-operatively. A radiological report of all pre-operative images was available in 17/128 (13%) cases.

The trend for all extractions of any tooth in Finland is presented in Table I. There was little annual variation in the number of teeth extracted according to this register.

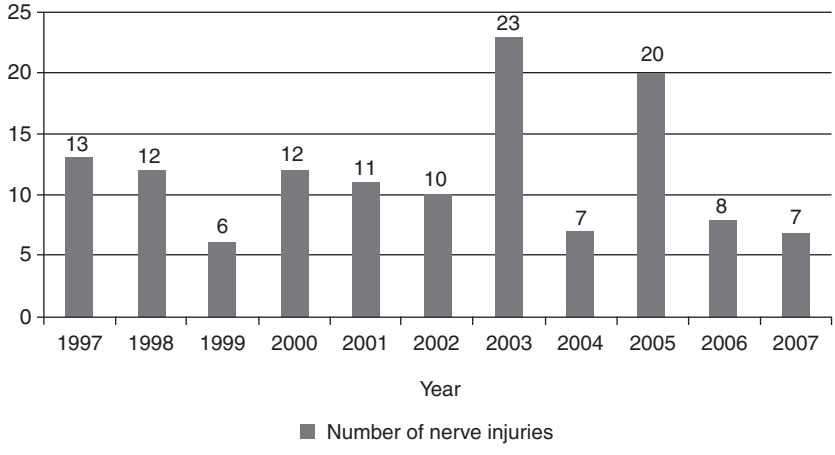

Figure 3. The number of completed cases of permanent IAN injuries related to the removal of mandibular third molars during the years 1997–2007 (according to malpractice claims made to FPIC).

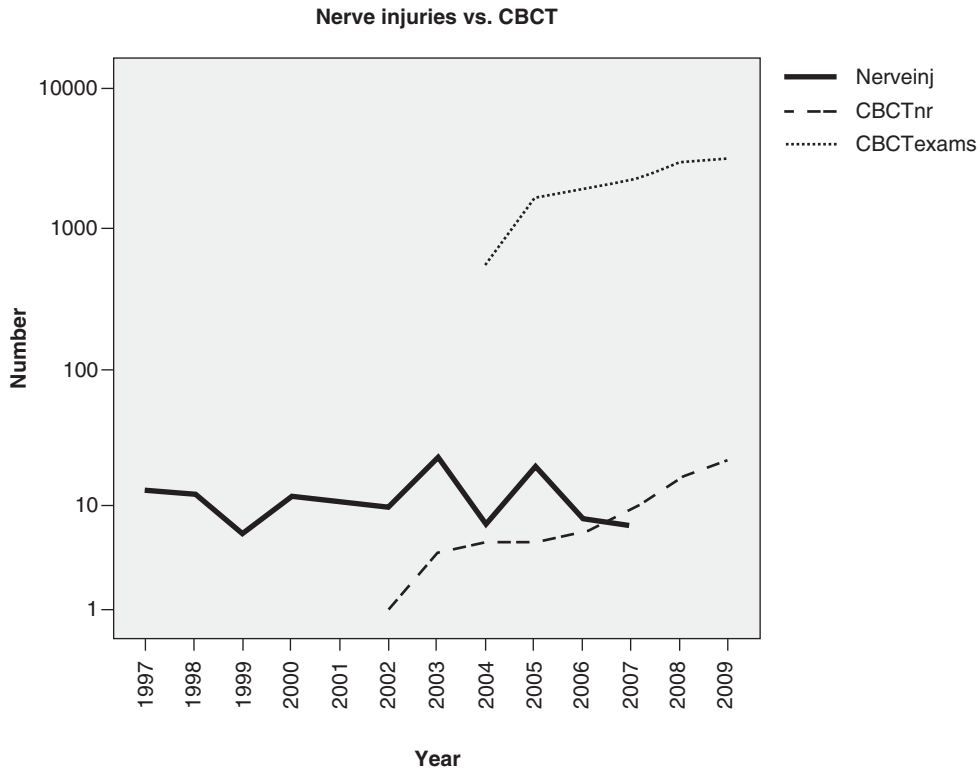

Figure 4. The number of new CBCT devices in Finland during the years 2002–2009, the number of reimbursed CBCT examinations in Finland during the years 2004–2009 and the number of reported permanent IAN injuries related to the removal of mandibular third molars during the years 1997–2007.

Discussion

The increase in the availability of CBCT had no significant impact on the number of IAN injuries. This was contrary to our hypothesis that the number of nerve injuries should diminish. In the present study the total number of permanent IAN injuries during the years 1997–2007 was 129, with a mean annual rate of 12. Previously, during the years 1987–1993 there were 62 claims for permanent IAN injuries associated with mandibular third molar removals in Finland, with a mean annual rate of nine [15]. Thus, the number of nerve injury claims in Finland seems to have increased. This may partly be due to patients' greater awareness of the insurance claim system. The clear female predominance among patients continues.

Table I. The annual total number of reimbursed tooth extractions during the years 2002–2007 in Finland according to the register of the Kela.

Year	Number of tooth extractions
2002	17 048
2003	18 467
2004	18 816
2005	17 569
2006	17 649
2007	17 785

The total number of nerve injuries is certainly higher than that for which claims have been made to FPIC. How well the possible complications have been discussed pre-operatively between the dentist and the patient is a vital factor. If the patient has signed the informed consent form and accepted the planned procedure, it is unlikely that a malpractice claim will be made.

Reliable pre-operative imaging helps the surgeon to plan the operation carefully, the patient can be referred to a specialist if needed or the operation may be cancelled in light of the imaging findings. The expertise and experience of the practitioner has been reported to be related to IAN injuries [15–17]. The incidence of complications associated with third molar removals is reported to be 4-times higher among inexperienced surgeons than experienced ones [16]. Ventä et al. [15] reported that more than half of all nerve injury claims relating to third molar removals involved dentists with less than 10 years' experience. In the study by Ventä et al. [15], 78% of those performing the operation were general dental practitioners, 15% oral and maxillofacial surgeons and 7% other specialists. In the present study 37% of the removals were done by an oral and maxillofacial surgeon. Even though the percentage of oral and maxillofacial surgeons was clearly higher in our study than in the earlier report [15], there were a higher mean number of IAN

injuries in our study. Thus, the expertise of the oral and maxillofacial surgeon did not prevent IAN injuries in a large number of cases in the present study. One reason for this could be that complicated cases are more often being referred to oral and maxillofacial surgeons than previously. Because most of the injuries were caused by general dental practitioners, we may assume that some cases dealt with by them were too difficult. In the present study the number of years of experience of those performing the procedure was not evaluated.

Pre-operative CT imaging for mandibular third molar removal has been found to be useful in complicated cases. According to Flygare and Öhman [6] no cases of persistent nerve damage associated with third molar surgery had occurred in their hospital after the introduction of pre-operative CT. In the present study pre-operative CT was performed in only two out of the 129 IAN injury cases, in both of which nerve injury was considered unavoidable. One of the two IAN injuries was related to an unavoidable angulus fracture during removal of a mandibular third molar with chronic pericoronitis. The other was related to the surgical removal of a mandibular third molar with a large keratocystic odontogenic tumor.

However, very little is known about the impact of CBCT on clinical management decisions, patient treatment and treatment outcome and studies of these questions are urgently needed. The benefits of CBCT devices are lower cost, smaller size, better availability for dental patients, and smaller radiation dose compared with conventional CT. Dose levels for CBCT imaging are far below those of clinical multislice CT protocols [18–21], which is an obvious benefit of CBCT.

In none of our IAN injury cases was a CBCT examination performed pre-operatively, whereas in 97% of cases pre-operative panoramic radiography was available. Since the indication for a CBCT examination is not registered at Kela, we do not know the total number of CBCT examinations related to mandibular third molar imaging. However, it can be expected that pre-operative CBCT examinations have helped to plan many safe removals. In a previous study conducted in a private practice in Finland more than 10% of the CBCT examinations were related to tooth, root or foreign body localization and most of these examinations were related to mandibular third molars [22]. In that study the most common indications for the use of CBCT were planning of a dental implant placement and diagnosis or exclusion of dental infection or peri-implantitis. It seems that, in spite of an increase in the availability of CBCT, it is not used routinely in difficult cases. It is likely that the imaging facility present at the referring ward (whatever it may be) has mainly been used for convenience and for economical reasons. The nearby availability of CBCT, but not its medical indication, may have been the main reason for its use. The most difficult cases have not found their way to CBCT.

One limitation of our study is that we do not know the true annual number of third molar extractions. Only the total annual number of extractions of any tooth was available from Kela's register during the years 2002–2007. However, since annual differences in the number of extracted teeth were small according to this register, we may expect that the proportion of mandibular third molar removals remained fairly constant. Another limitation is the short follow-up time of the most recent IAN injuries. An injury that occurred late in 2007 may not be caught because the follow-up time was only 2.5 years and not 3 years (up to summer 2010). Patients have to submit their claim within 3 years. For this reason a very small number of cases may not yet have been completed and thus have been missed.

In conclusion, there was no evidence of a decrease in nerve injuries, despite the greater availability of CBCT. However, in the years 2006 and 2007 the number of IAN injuries was smaller than the mean number of IAN injuries during the study period, which is a promising finding. Future studies with a longer follow-up period are needed to analyze the impact of CBCT on the incidence of nerve injuries. Another approach might be to examine all cases with pre-operative CBCT imaging and to evaluate how many of them resulted in nerve injury. More education should be given to optimize the use of CBCT to cover the difficult cases likely to involve complications.

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