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CASE REPORT

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Failure to obtain adequate anaesthesia associated with a bifid mandibular canal: a case report

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Abstract

The inferior alveolar nerve (IAN) block is the most common method for obtaining mandibular anaesthesia in dental practice but it is estimated to have a success rate of only 80 to 85 per cent. Causes of failure include problems with operator technique and anatomical variation between individuals. This case report involves a patient who received IAN blocks on two separate occasions that resulted in only partial anaesthesia of the ipsilateral side of the mandible. Radiographic assessment disclosed the presence of bifid mandibular canals that were present bilaterally and that may have affected the outcomes of the local anaesthetic procedures. Previous studies of bifid mandibular canals are reviewed and suggestions provided that should enable clinicians to differentially diagnose, and then manage, cases where IAN blocks result in inadequate mandibular anaesthesia.

Key words: Local anaesthesia, complications, anatomy, inferior alveolar nerve, humans.

Abbreviations and acronyms: ADH = Adelaide Dental Hosptial; IAN = inferior alveolar nerve; LA = local anaesthesia; PDL = periodontal ligament; SADS = South Australian Dental Service.

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INTRODUCTION

Administration of an inferior alveolar nerve (IAN) block is the most common method of mandibular anaesthesia used in dental practice. However, it is widely recognized that profound anaesthesia of half of the mandible is not always achieved following this procedure. Indeed, Kaufman *et al.*[1] have estimated that the IAN block provides only an 80 to 85 per cent success rate which is lower than that of other nerve blocks in the maxilla. Keetley and Moles[2] claimed a higher success rate of 91.9 per cent in a study where 580 IAN blocks were given. As the administration of the IAN block is such a commonly used form of local anaesthesia, a thorough understanding of the possible causes of failure and their respective management is essential.

There are many causes of failure of IAN blocks, including poor technique, anatomical variation, the presence of an acute infection, inability to introduce the needle to the appropriate site or a reduced pain threshold.[3] This case study focuses on one example of anatomical variation, the presence of a bifid mandibular canal.

There have been several investigations in the past of the prevalence of bifid mandibular canals but relatively few recent reports. In a study of 3612 panoramic radiographs in the 1970s, 33 individuals or 0.9 per cent were found to have a duplication or division of the IAN canal.[4] A study in the 1980s yielded a similar prevalence of bifid mandibular canals (0.95 per cent) based on an analysis of 6000 panoramic radiographs.[5] In contrast, Grover and Lorton[6] reported a prevalence of only 0.08 per cent after studying 5000 panoramic radiographs of US army recruits. In more recent times, Sanchis *et al.*[7] showed a prevalence of 0.35 per cent from the analysis of 2012 panoramic radiographs.

CASE REPORT

A 63-year-old male patient, who was receiving routine general dental care including the placement of restorations in mandibular teeth, was seen in 2004 by the first author at the Adelaide Dental Hospital (ADH). He had a history of non-insulin dependent diabetes mellitus that was well-controlled. His dental history indicated a poor attendance rate due to a lack of concern about his own oral health with the main reason for attendance being pain relief. The patient's standard of oral hygiene was poor when seen initially but improved once oral hygiene instruction was commenced. He had a history of moderate chronic generalized periodontitis.

On the first visit, an IAN block, including deposition of anaesthetic solution to block the lingual nerve, was given on the left side before treatment of a carious lesion on the distal surface of the 36 was commenced. A total of 2.2ml of 2% lignocaine HCl with 1:80000 adrenaline

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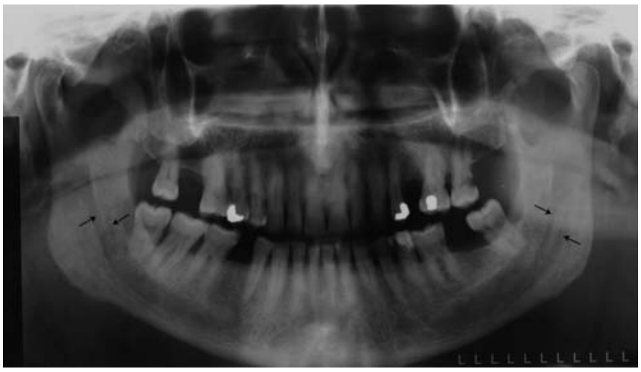

Fig 1. Panoramic radiograph showing bifid mandibular canals. On the left side the presence of a bifurcation of the mandibular canal is evident, with two distinct radiographic images of the canals with separate origins. The right side of the mandible also displayed an apparent bifurcation of the mandibular canal as well, but at a higher level. The two canals were separate as well, originating from two different foramina.

was injected. The main intra-oral landmarks, including the pterygomandibular fold, pterygotemporal depression and coronoid notch could all be located without difficulty. Although some soft tissue anaesthesia of the left side of the mandible was obtained after five minutes, including the lip and tongue, the periodontal tissues surrounding the 36 and the tooth itself were still sensitive. Sensitivity of the gingivae and alveolar mucosa around the 36 was assessed by the use of the tip of a dental probe and the sensitivity of the 36 itself was detected once caries removal via the use of a slow speed handpiece had commenced. The patient described the pain as sharp and very uncomfortable. As the majority of the caries removal had already been completed, on the patient's request, the remaining infected dentine was removed using a spoon excavator without supplementary local anaesthesia (LA). The patient's threshold to pain was deemed to be relatively high as he had undergone subgingival scaling of his mandibular anterior teeth during previous appointments without the need for any LA.

On a second visit about two months later, another IAN block was required on the left side prior to replacement of the temporary restoration in the 36 (Fig 1). During insertion of the needle into the pterygomandibular space, the patient reported a sharp pain that radiated down the left side of the mandible like an electric shock. This is usually associated with the needle touching the inferior alveolar nerve. The needle was withdrawn slightly and re-inserted close to its original position with minor changes to its angulation. After aspirating, anaesthetic solution (of the same type and amount as previously) was deposited near the IAN and then adjacent to the lingual nerve to block them both. After five minutes the patient exhibited partial soft tissue anaesthesia that seemed to be more profound towards the anterior mandibular region on the left side. As before, following the patient's request, no further LA was given and the minimally-invasive operative treatment was managed with little discomfort.

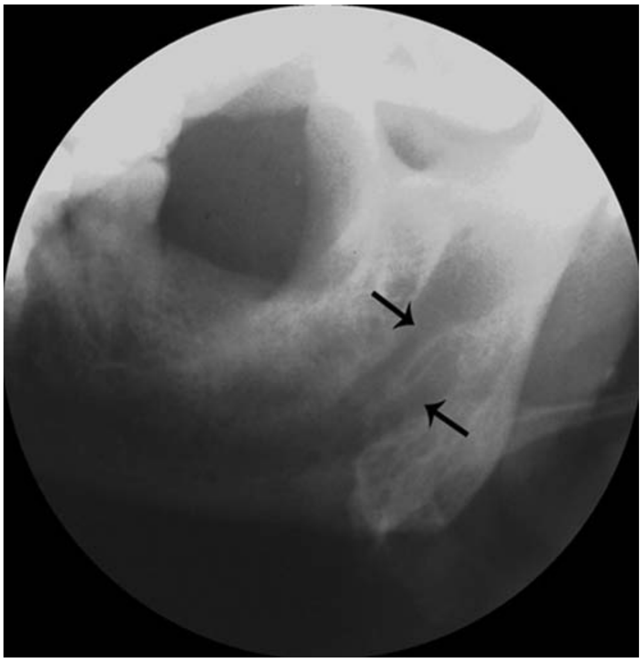

Fig 2a. Left lateral oblique mandibular projection. This radiograph clarifies the relationship between the two separate IAN canals and affords a slightly magnified view of the mandibular ramal area.

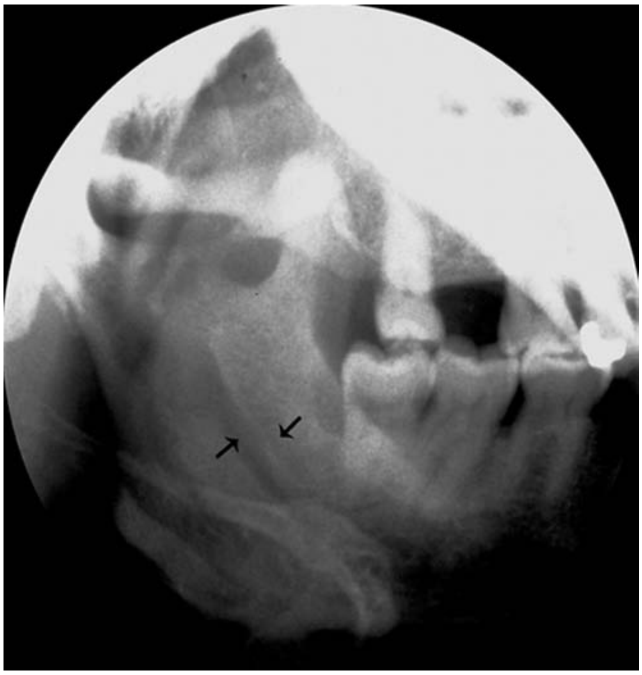

Fig 2b. Right lateral oblique mandibular projection. In this radiograph it is more difficult to discern two separate IAN canals due to poorer contrast.

A panoramic radiograph obtained previously during 2004 (Fig 1) indicated the presence of a bifurcation of the mandibular canal on the left side of the mandible, with two distinct radiographic images of the canals with separate origins that appeared to join anteriorly to form a single canal in the area below where the 37 would be located. It would seem most likely that the more postero-inferiorly located canal was supplementary in nature, not only because it seemed to be located more inferiorly than normal but also because it lacked the characteristic 'funnel'-shaped radiolucency that is normally visible at the most superior portion of the mandibular canal and which correlates with a depression on the medial surface of the ramus above the mandibular foramen. Unfortunately, a large radiolucency, probably representing the submandibular salivary gland fossa, obscured the path of the canal from that point onwards.

The right side of the mandible also displayed an apparent bifurcation of the mandibular canal but at a higher level. On this side, it would seem that the shorter, antero-superiorly positioned canal was accessory to the main canal for similar reasons to those given above. The two canals appeared to be distinct, originating from two separate foramina. The presence of a large radiolucency below the molars, again probably the submandibular gland fossa, obscured the canals, making it difficult to ascertain at which point they joined together.

With the patient's consent, a lateral oblique radiograph of each mandibular ramus was obtained to clarify the nature of the bifid mandibular canals. While the lateral oblique mandibular projection on the left side was useful and allowed us to visualize the pathway of the two separate mandibular canals more clearly (Fig 2a), the radiograph on the right side (Fig 2b) was not as clear in revealing the two canals due to superimposition of the hyoid bone. The lateral oblique radiographs appeared to support the evidence obtained from the panoramic radiograph that the bilateral bifid mandibular canals on each side originated from separate foramina.

DISCUSSION

Malamed[8] has stated that the 80 to 85 per cent success rates for the IAN block reported by Kaufman *et al.*[1] reflect anatomical variations in mandibular anatomy, such as increased density of cortical bone, and that for optimal effect the needle tip should be placed within 1mm of the IAN. However, variations in the size and shape of the mandible, the position of the mandibular foramen on the medial surface of the ramus,[9] and the depth of soft tissue penetration required, all impact on accurate placement of the needle tip and therefore successful anaesthesia. Even the sphenomandibular ligament, that varies considerably between individuals, may act as a barrier to diffusion of anaesthetic solution.[10]

Although it is generally thought that the IAN travels completely within the mandibular canal for its entire length, with small branches on the ipsilateral side providing innervation to the pulps of teeth, accessory innervation is possible. For example, the most documented source of accessory innervation is the mylohyoid nerve. Although the mylohyoid nerve is commonly believed to provide accessory innervation to the mandibular incisors mainly, the nerve also supplies other mandibular teeth.[11,12] The overall prevalence of the mylohyoid nerve providing some degree of accessory innervation to the mandibular teeth is thought to be approximately 60 per cent.[13]

The presence of retromolar foramina has also been associated with accessory innervation of mandibular molars and has been proposed to be responsible for failure of the traditional IAN block.[14,15] The nerve which is thought to provide accessory innervation in these situations is the long buccal nerve (a branch of the anterior division of the mandibular nerve) or perhaps even accessory branches of the IAN.[16]

The course of the IAN within the mandible is very variable, contrary to common thought. Carter and Keen[17] found that in only 49 of the 80 (61 per cent) radiographs that they examined did the IAN and its neurovascular bundle appear to stay completely within the mandibular canal. They also reported possible accessory innervation of the first and third molars by direct communication of the IAN with nerves that entered the mandible in the retromolar region.

From an embryological perspective, the presence of mandibular canal variants can be explained by the spread of intramembranous ossification that commences where the IAN divides into mental and incisive branches around seven weeks in utero. The extension of ossification posteriorly along the lateral border of Meckel's cartilage produces a gutter around the IAN that eventually forms the mandibular canal.[18] Branching of the IAN or communications with other nerves would be reflected in various types of mandibular canal morphology.

Nortjé *et al.*[4] reported that there were three main variants of mandibular canal division or duplication: the first consisting of two canals with a common foramen; the second being a short additional canal lying anterior-superior to the longer canal and extended to the second or third molars; and the third being two distinctly separate mandibular canals arising from separate foramina that eventually joined to form a single canal towards the anterior portion of the mandible. In their study, type I variation was most common having a 0.72 per cent prevalence overall, type II variation had a 0.14 per cent prevalence, and type III variation was least common having a 0.06 per cent prevalence. Another radiographic study by Langlais *et al.*[5] also revealed similar variations, with four different patterns of bifid mandibular canals being described. The first included bifid canals extending to the area surrounding the third molar or to the tooth itself; the second included bifid canals arising from the same foramen but forming two separate canals which rejoined to form a single canal anteriorly in the mandible; the third type included a combination of the first two types; and the last type included two radiographically separate canals with separate origins that eventually fused into a single canal anteriorly. In the study by Langlais *et al.*,[5] type I variation had a prevalence of 0.367 per cent, type II variation was most common with a prevalence of 0.517 per cent, and types III and IV were the most uncommon with the prevalence for both being 0.0333 per cent. In both of the above studies, there was no statistically significant difference in the prevalence of bifid mandibular canals between males and females.

It is interesting to note that the panoramic and mandibular lateral oblique radiographs obtained of the patient in this case report showed evidence of a bifurcation of the IAN canal on both left and right sides. This type of variation falls into the type III category defined by Nortjé *et al.*[4] or the type IV variation defined by Langlais *et al.*[5] These were the least common types of variation reported. Interestingly, a recent case report has shown that a trifid mandibular canal is also possible.[19]

While it is tempting to assume that the presence of bifid mandibular canals is synonymous with bifid IANs, it is possible that these canals may only surround blood vessels instead of both blood vessels and nerves.[4] Possible support for this suggestion comes from the findings of a study by Grover and Lorton[6] in which four patients, who seemed to have bifid IANs based on examination of their panoramic radiographs, did not report having any previous difficulty with mandibular anaesthesia. In contrast, Sanchis *et al.*[7] have reported that the presence of bifid mandibular canals is associated with increased difficulty in obtaining mandibular anaesthesia with the conventional IAN block. The most conclusive way to determine the contents of accessory IAN canals would be histological analysis after dissection but, of course, this was not possible in this case report. It is also possible that the additional mandibular canal on the left side, shown in Fig 1, may contain the mylohyoid nerve, due to its position in the ramus. However, this is much more unlikely on the right side as the additional canal on that side is superior to the main one.

As there are many possible reasons for failure to obtain profound mandibular anaesthesia, we need to be able to differentially diagnose these causes and manage them accordingly. Conventionally, the presence of profound soft tissue anaesthesia of the ipsilateral lip, chin and teeth is indicative of an effective IAN block. If a patient experiences only soft tissue anaesthesia around the injection site, but not of the ipsilateral lip or chin, then a problem with LA technique is likely to be the cause of the failure. However, if there is soft tissue anaesthesia of the lips and chin but not the teeth, one should consider anatomical variation.

If the problem is considered to be due to a problem with LA technique, a repeat IAN block should prove effective provided the operator is able to correct his or her technique. If the problem is thought to involve anatomical variation, other types of LA technique are indicated, as repeating the same procedure is likely to be ineffective and may result in increased postoperative pain and even trismus.[8] It is of particular interest that in this case report, the patient displayed a combination of signs and symptoms that increased the difficulty of diagnosing the likely cause of failure of the LA. It would have been relatively easy to overlook the fact that, while the posterior soft and hard tissues on the ipsilateral side were still relatively sensitive, anaesthesia became increasingly profound anteriorly with the lips and chin being numb. If it had only been recognized that the soft and hard tissues around the 36 had not been effectively anaesthetized, a conclusion may have been drawn that the most likely cause of the failure was poor LA technique. The observation that aided diagnosis was that during the administration of LA on the second visit, the IAN was touched by the needle tip causing a classic radiating 'electric shock' response. It was therefore reasonable to assume that the needle tip was very close to the IAN and that if the anaesthetic solution were to be deposited at the intended site, profound anaesthesia should be obtained. The subsequent failure to obtain adequate anaesthesia was a surprising result and, when considered together with the history of previous failure to obtain anaesthesia of the same side of the mandible, triggered the decision to undertake further tests of sensation on the entire ipsilateral side of the mandible.

Alternative methods of obtaining adequate anaesthesia in these situations include buccal and lingual infiltrations, the Gow-Gates mandibular nerve block or the Vazirani-Akinosi closed mouth mandibular block. The rationale for use of the Gow-Gates block procedure is that it is a true mandibular block that aims to anaesthetize virtually all of the sensory branches of the mandibular nerve in the infratemporal fossa whereas the conventional IAN block aims to anaesthetize the IAN alone at the level of the lingula. Thus, it is hypothesized that the Gow-Gates block should be more effective in providing anaesthesia of the ipsilateral mandible by blocking accessory IANs above the point where they branch.[20] Other alternatives include use of the periodontal ligament (PDL) injection, the intra-osseous approach and possibly intrapulpal injections to anaesthetize individual teeth.[21]

CONCLUSION

While separate mandibular foramina associated with a bifid mandibular canal are relatively rare, they may affect the ease with which anaesthesia can be achieved in the mandible when using a conventional IAN block. Although it may seem convenient to merely re-administer another IAN block, one should analyse each situation carefully when anaesthesia is inadequate to determine the most likely cause of failure before attempting a repeat performance or use of an alternative LA technique. If the problem is thought to be due to problems with technique, a repeat of the IAN block that accounts for the perceived technical problems will usually be sufficient. However, based on the findings of this case report, it would seem prudent to assess any available panoramic radiographs of patients for the presence of unusual mandibular anatomical features before administration of LA is commenced. If anatomical variation is suspected, based on radiographic findings and a history of failure to obtain anaesthesia after the delivery of a standard IAN block, alternative methods of LA should be considered.

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