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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 Hospital; 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 Moles2 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 Lorton6 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
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.

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\(^1\) 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,\(^5\) 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 Nortje 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.6

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.7
Possible support for this suggestion comes from the
findings of a study by Grover and Lorton6 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.8 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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