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Accessory mandibular foramina and bifid mandibular canals - an anatomical study

Gyanaranjan Nayak[1], Niranjan Sahoo[2], Sitansu Panda[1]

[1]Department of Anatomy, IMS and SUM Hospital, Siksha 'O' Anusandhan Deemed to be University, Bhubaneswar, Odisha, India, [2]Department of Forensic Medicine and Toxicology, IMS and SUM Hospital, Siksha 'O' Anusandhan Deemed to be University, Bhubaneswar, Odisha, India

SUMMARY

Bifid mandibular canals associated with accessory mandibular foramina are claimed to pose complications in oral surgery and allied procedures resulting in paraesthesia and haemorrhage, due to injury to the divisions of inferior alveolar nerves and vessels passing through them. Sometimes these nerves escape the effect of anaesthetics leading to difficult inferior alveolar nerve block. These variant canals serve as a source of spread of cancer from cortical to cancellous part of the mandible. The current descriptive study included thirty intact, dry, adult human mandibles. They were examined macroscopically to note the presence of accessory mandibular foramina and the accessory mandibular canals arising from them. These aberrant canals were probed and their length was noted. The probed mandibles were X-rayed to observe the course of these canals. The location of the foramina was determined from nearby anatomical landmarks.

Six mandibles (20%) showed accessory mandibular foramina. The length of the accessory mandibular canals originating from the accessory mandibular foramina was found to vary from 0.9 cm to 4.5 cm. On X-ray films, the variant canals were noted to proceed towards third molar or towards the angle of mandible. Some of these canals merged with the main mandibular canal. The findings of the study will be helpful in oral surgery, radiology and cancer therapy.

Key words: Accessory mandibular foramen – Bifid mandibular canal – Oral surgery – Inferior alveolar nerve block

INTRODUCTION

Mandibular canals extend from mandibular foramen to mental foramen and transmit inferior alveolar vessels and nerve. These nerves and vessels provide somatic sensations and blood supply to teeth of the lower jaw, interdental papilla and periodontal as well as alveolar bone tissues (Nortze et al., 1977; Jacobs et al., 2007; Natioh et al., 2009; Kalantar Motamedi et al., 2015). Mandibular canals are usually single on each ramus of the mandible. However, variations like bifid mandibular canals or retromolar canals may exist, and can lead to complications during intraoral dental and surgical procedures such as third molar extraction, osteotomy for bone grafting and placing implants (Teerijoki-Oksa et al., 2002; Natioh et al., 2009; Kawai et al., 2012; Kalantar Motamedi et al., 2015). The common complications are somatosensory impairment during and after surgery, post-traumatic neuroma and hemorrhage (Clayes and Wackens, 2005; Silva et al., 2006; Renton et al.,

Corresponding author: Dr Gyanaranjan Nayak. Department of Anatomy, IMS and SUM Hospital, Siksha 'O' Anusandhan Deemed to be University, Bhubaneswar, Odisha 751003, India.
Phone: 09937750477.
E-mail: drgrn82@gmail.com

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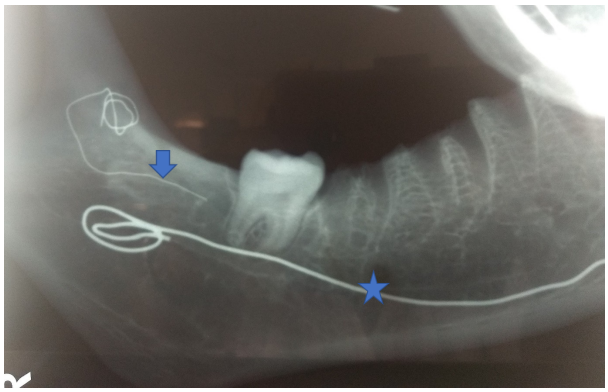

Fig 1. Accessory mandibular canal (arrow head) going towards third molar. Mandibular canal is marked by star.

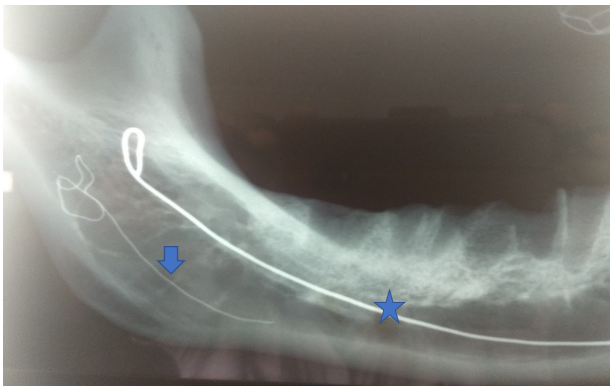

Fig 2. Accessory mandibular canal (arrow head) going to angle of mandible and parallel to mandibular canal (star) throughout its course.

Table 1. Length of mandibular and accessory mandibular canals in variant mandibles.

Serial No of mandibles	Left Mandibular canal (cm)	Right Mandibular canal(cm)	Left accessory Mandibular canal (cm)	Right accessory Mandibular canal (cm)
1	4.2	6.1	1	
2	5.8	6.5	1.8	
3	5.6	4	0.9	1
4	6.5	5.7	2.3	2.2
5	7.6	3.7	2.7	2.1
6	5.6	5	4.5	3.9
Mean ± SD (cm)	5.88 ± 1.12	5.16 ± 1.13	2.2 ± 1.32	2.3 ± 1.19

Table 2. Distance of mandibular and accessory mandibular foramina from mandibular notch in variant mandibles.

Serial No of mandibles	Left mandibular foramen (mm)	Right mandibular foramen (mm)	Left accessory Mandibular foramen (mm)	Right accessory Mandibular foramen (mm)
1	22	20.5	15.88	
2	22.5	22	12.55	
3	18	17	13	16
4	22	21	18.55	14.5
5	20	24	19.5	18
6	20	19	17	17
Mean ± SD (mm)	20.75 ± 1.72	20.58 ± 2.41	16.06 ± 2.85	16.37 ± 1.49

2012). Accessory mandibular foramen is any opening on the medial surface of the ramus of the mandible other than mandibular foramen, mental foramen, accessory mental foramen, lingual foramen and sockets of teeth (Shalini et al., 2016). The 'accessory mandibular foramina' are defined as any accessory foramina on the medial surface of the mandibular ramus. The accessory mandibular foramen usually gives rise to the accessory mandibular canal. If the accessory mandibular foramen is single, the mandibular canal becomes bifid due to the lone accessory canal arising from such foramen (Kaufman et al., 2002; Shalini et al., 2016). The presence of accessory mandibular foramina and double or bifid mandibular canals extending from them may give rise to anaesthetic failure, as divisions of the inferior alveolar nerve may pass through the said foramen and canal, and provide accessory innervation to the mandibular teeth (Kaufman et al., 2002). Neufeld (1985) has opined that an accessory foramen and overlying periosteum may directly communicate with the cancellous bone of the mandible. This may play an important role in bony invasion of the medial surface of the mandible, particularly so in irradiated mandibles. This can be attributed to the fact that radiotherapy decreases the ability of the periosteum to act as a barrier to the spread of a tumour

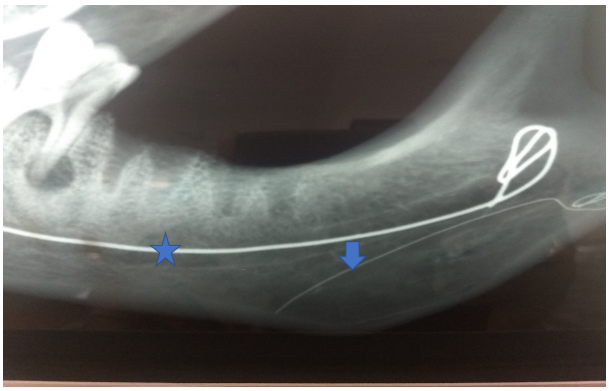

Fig 3. Accessory mandibular canal (arrow head) going to angle of mandible and parallel to mandibular canal (star) in initial course to diverge later.

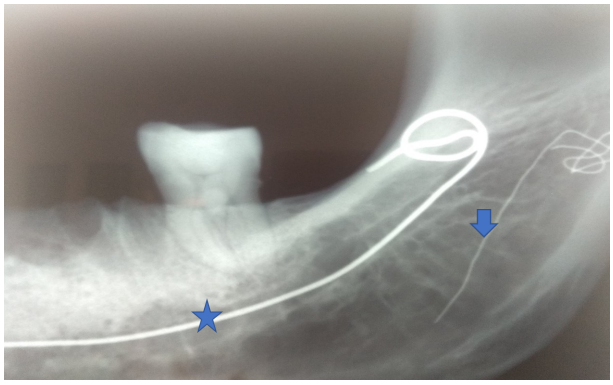

Fig 4. Accessory mandibular canal (arrow head) going to angle of mandible and diverges from mandibular canal (star) throughout its course.

Table 3. Distance of mandibular and accessory mandibular foramina from angle of mandible in variant mandibles.

Serial No of mandibles	Left Mandibular foramen (mm)	Right Mandibular foramen (mm)	Left accessory Mandibular foramen (mm)	Right accessory Mandibular foramen (mm)
1	18	18.7	25.14	
2	25	24	36	
3	25.5	27.5	29	30
4	23	22	26.5	26
5	23	23	24	23.9
6	25	24	27.5	26
Mean ± SD (mm)	23.25 ± 2.78	23.2 ± 2.88	28.02 ± 4.28	26.47 ± 2.55

Table 4. Distance of mandibular and accessory mandibular foramina from anterior border of ramus of mandible in variant mandibles.

Serial No of mandibles	Left Mandibular foramen (mm)	Right Mandibular foramen (mm)	Left accessory Mandibular foramen (mm)	Right accessory Mandibular foramen (mm)
1	15	15.6	20.69	
2	17.5	12.5	19	
3	16	19	16	17.5
4	18	16	21.5	22
5	17.5	16	22.5	20.5
6	20.5	20	19	17
Mean ± SD (mm)	17.41 ± 1.88	16.51 ± 2.67	19.78 ± 2.31	19.25 ± 2.39

(McGregor and McGregor, 1986). Hence, the knowledge of the number and preponderance of these variant foramina and canals could provide insight into the mode of spread of tumours within the cortical layer of the mandible. Due to their overwhelming importance in oral surgery, inferior alveolar nerve block and radiotherapy of mandibular tumour, the current study was undertaken to find out the incidence and to do the morphometry of the accessory mandibular foramina and bifid mandibular canals.

MATERIALS AND METHODS

The study included thirty numbers of dry, human, adult mandibles used to teach osteology in routine MBBS (Bachelor of Medicine and Bachelor of Surgery) classes in a Medical College of Eastern India. The mandibles belonged to individuals of Indian race. Twenty- two mandibles belonged to males, whereas eight belonged to females. All the thirty mandibles had developed third molar. So it was concluded that all of them belonged to persons who were at least eighteen years or older. The dental formula was found to be I 2\2, C 1\1, PM 2\2, M 3\3 (I- Incisor, C- Canine, PM- Premolar, M- Molar). Mandibles with obvious deformities and pathological changes were excluded from the study. All the mandibles were studied macroscopically to note the presence of accessory mandibular

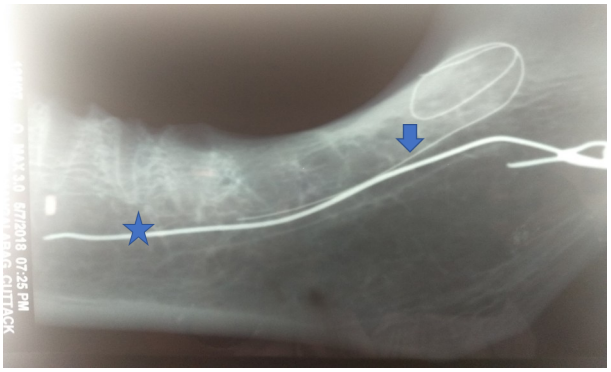

Fig 5. Accessory mandibular canal (arrow head) merging with the mandibular canal (star).

Serial No of mandibles	Left side (mm)	Right side (mm)
1	7	
2	11	
3	2.5	2
4	4	10
5	8.5	7
6	2	2
Mean ± SD (mm)	5.83 ± 3.58	5.25 ± 3.94

Table 5. Distance between mandibular foramen and accessory mandibular foramen in variant mandibles.

foramina. The location of the regular and accessory mandibular foramina was determined from the nearby anatomical landmarks like mandibular notch, angle of mandible and anterior border of mandibular ramus with the help of a digital Vernier Callipers (Model No 500-196-20 of Mitotoyo Manufacturing Company, Japan) in the variant mandibles. The distances were measured thrice to avoid interobserver variation, and the mean of the three values was taken as the final measurement. Graduated metallic probes were inserted both into regular as well as accessory mandibular foramina to note the length of the regular and accessory mandibular canals extending from the said foramina. The mandibles were radiographed with the respective probes in place within the regular and accessory mandibular canals, so that the course and termination of the regular and accessory canals could be determined. The observations were recorded in tabular form.

RESULTS

Six mandibles out of thirty (20%) showed the presence of accessory mandibular foramina. The accessory mandibular foramina were bilateral in four mandibles and unilateral in two mandibles. All of them were present on the medial surface of the ramus of the mandible. Each ramus of the variant mandible presented only a single accessory foramen. Out of the ten accessory foramina, six were left-sided and four were right-sided. Both the unilateral accessory mandibular foramina were on the left side. The location of accessory mandibular foramina was both in front and behind the regular foramina. The length of the regular mandibular canal in the variant mandibles was recorded to be from 3.7 cm to 7.6 cm. On the other hand, the bifid mandibular canals measured between 1 cm to 6.5 cm. The length of the canals and distance of the foramina from nearby anatomical landmarks are displayed for the six variant mandibles, and are depicted in Table 1 to Table 4. Table 5 depicts the distance between the regular and accessory mandibular foramen in the six variant mandibles.

On X-ray of the probed mandibles, it was found that the bifid mandibular canals presented with three basic patterns. They are as follows:

Accessory mandibular canal going to third molar (Fig. 1). There were five such canals, four bilateral and one unilateral.

Accessory mandibular canal going to the angle of the mandible (Figs. 2, 3, 4). There were three such canals, two bilateral and one unilateral.

Accessory mandibular canal merging with the regular canal (Fig. 5). There were a couple of such canals, both bilateral.

The second variety is further subdivided as follows:

Accessory mandibular canal parallel to main mandibular canal throughout its course (Fig. 2). There was one such canal.

Accessory mandibular canal parallel to the main canal in initial course to diverge later (Fig. 3). There was one such canal.

Accessory mandibular canal diverges from main mandibular canal throughout its course (Fig. 4). There was one such canal.

We are steering clear of proposing any classification of the course of bifid mandibular canals, as that needs to be confirmed by Cone Beam Computerized Tomography (CBCT).

DISCUSSION

Accessory mandibular foramina were observed in 20% cases in our study. Padmavathi et al. (2014) have found an incidence of 41.5% in their study in South India. Samanta and Kharb (2013) have reported an incidence of 16.6% in the Noida region of North India. Murlimanju et al. (2011) have proposed an incidence of 16.4% in South India. Authors like Freire et al. (2012) and Sutton (1973) have also reported accessory mandibular foramina in their respective studies.

We have done the morphometry of mandibular and accessory mandibular foramina in the variant mandible, which is comparable to other studies (Sutton, 1973; Murlimanju et al., 2011; Freire et al., 2012; Samanta and Kharb, 2013; Padmavathi eet al., 2014).

We have found out three basic patterns of bifid

mandibular canals similar to studies done by Carter and Keen (1971) and Nortze et al. (1977).

Carter and Keen (1971) have classified the intramandibular course of the inferior alveolar nerve into three basic types. They are as follows:

Type I- The inferior alveolar nerve is a single large structure lying in a bony canal.

Type II- The nerve is situated substantially lower in the mandible.

Type III- The inferior alveolar nerve separates posteriorly into two large branches. Type III is supposed to correspond to bifid mandibular canal.

Nortze et al. (1977) have proposed various types of bifid mandibular canal. They are as follows:

Type I- Two canals originating from one foramen.

Type II- A short supplemental upper canal extending to the second or third molar.

Type III- Two mandibular canals of equal dimensions apparently arising from separate foramina in the mandibular ramus, and joining to form one canal in molar region.

Type IV- A supplemental canal arising in the retromolar pad region and joining with the main canals in the retromolar area.

We have found bifid mandibular canals similar to Type II and Type III pattern of Nortze et al. (1977). Das and Suri (2004) have also reported a case with the accessory mandibular canal terminating close to the root of third molar.

The formation of bifid mandibular canal has got an embryological basis (Chavez-Lomeli et al., 1996). There might be three inferior alveolar nerves innervating the three groups of deciduous mandibular teeth. During rapid prenatal growth and remodelling in the ramus region, there is spread of intramembranous ossification that eventually forms the single mandibular canal. So the presence of bifid or trifid mandibular canals can be explained on the basis of incomplete fusion of these nerves, as the nerves get formed first with succeeding mesenchymal condensation around them forming the mandibular canals.

The knowledge of the presence of accessory mandibular foramen and bifid mandibular canal is important in performing inferior alveolar nerve block. Branches of inferior alveolar nerve passing through accessory mandibular foramen may escape the nerve block. So it is advocated to perform the nerve block at a higher level than usual (Gow-Gates technique).

This procedure involves application of anaesthetic solution at a higher level before branching of inferior alveolar nerve from mandibular nerve (Meechan, 1999).

Oral surgeons should keep bifid mandibular canals in mind while performing osteotomies of the mandible or placing oral implants to avoid haemorrhage, paraesthesia or post traumatic neuromas due to damage to vessels and nerves passing in the bifid mandibular canals (Teerijoki-Oksa et al., 2002; Kawai et al., 2012; Kalantar Motamedi et al., 2015).

Accessory mandibular foramina provide a possible route of spread of tumour from the cortical to the cancellous part of mandible (O'Brien et al., 1986). The resistance to spread of tumour was found to be diminished in irradiated mandibles (McGregor and MacDonald, 1987). So in irradiated mandible, the accessory foramina communicating directly with cancellous bone may play a more obvious role in greater spread of tumour.

The minute size of accessory mandibular foramina limits their detection in regular skiagrams. Panoramic radiographs of the mandible have inadequacies like distortion, overlap and magnification that may lead to false interpretation of anatomical structures (Pancer et al., 2014). So various authors (Pancer et al., 2014; Haas et al., 2016) have suggested cone beam tomography (CBCT) as an accurate radiographic technique to visualize the accessory mandibular foramen. However, the higher cost and high levels of radiation exposure associated with CBCT limits its usage in routine clinical practice. Thus it is imperative to keep in mind the probable presence of accessory mandibular foramen and bifid mandibular canals and the possible complications arising out of their presence in routine clinical practice.

Conclusion: The findings of the study will be useful in dental surgery, as well as anaesthetic practice and radiotherapy.

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