ORIGINAL ARTICLE

Morphological Variations in the Inferior Alveolar Canal Detected through Cone Beam Computed Tomography (CBCT): A Retrospective Study

Abdullah Ali Alharbi [1], Shaul Hameed Kolarkodi [2],

ABSTRACT

Introduction

The inferior alveolar canal (IAC) is a critical anatomical structure in the mandible, extending from the mandibular foramen to the mental foramen. It contains the inferior alveolar nerve, artery, and vein, which provide sensation and blood to mandibular teeth and surrounding tissues. Variations in the IAC, including bifid, trifid, or pseudo-bifid configurations, can complicate dental and maxillofacial procedures. Cone Beam Computed Tomography (CBCT) allows detailed visualization of the IAC and aids in identifying these morphological variations.

Objective

This study aimed to evaluate the prevalence and characteristics of IAC morphological variations using CBCT in a Saudi Arabian population.

Methodology

This retrospective study analysed 1,006 CBCT scans from the College of Dentistry at Al-Qassim University, Saudi Arabia. Two trained observers independently examined the CBCT images for IAC variations, including bifid, trifid, and double mandibular canals. Discrepancies were resolved through consensus. The study used chi-square tests to determine associations between variables, with a significance level of $p < 0.05$. Demographicinformation and canal types were recorded, and variations were classified into five types.

Results

The study revealed that 19.78% of participants exhibited some form of IAC variation,with a significant gender-based difference: 70.4% of those with variations were male, while 29.6% were female. The most common canal type was Type II (bifid mandibular canals), accounting for 35.2% of cases, followed by Type I (32.2%) and Type III (23.6%). The distribution of canal types across genders indicated that males exhibited a higher prevalence in certain canal types and regions.

Conclusion

The findings underscore the critical role of CBCT in preoperative planning for dental and maxillofacial surgery, with a focus on identifying potential IAC variations.

Keywords

Inferior Alveolar Canal (IAC), Cone Beam Computed Tomography (CBCT), Bifid Mandibular Canal, Dental and Maxillofacial Surgery Risk Assessment

INTRODUCTION

The inferior alveolar canal (IAC) is an important anatomical structure in the mandible, extending from the mandibular foramen to the mental foramen [1]. It houses the inferior alveolar nerve, artery, and vein, which supply sensation and bloodto the mandibular teeth and surrounding tissues [2]. Structural variations in the IAC, including bifid, trifid, or pseudo-bifid configurations, can lead to complications during dental and maxillofacial procedures, such as nerve injury,bleeding, and sensory loss [3].

Cone Beam Computed Tomography (CBCT) is a sophisticated imaging modality that allows detailed examination of the IAC, providing clinicians with the ability to detect these morphological variations accurately [4]. Research suggests that bifid mandibular canals can be foundin up to 1.3% of the population, indicating a need for careful preoperative planning and risk assessment. The identification of these variations is critical, as they can complicate procedures like third molar extractions, dental implant placements,and orthognathic surgeries [5,6].

The aim of this retrospective study is to evaluate the prevalence and characteristics of

1 Dental Intern, College of Dentistry, Qassim University, Buraydah, Qassim, Saudi Arabia

2 Department of Oral and Maxillofacial Diagnostic Sciences, College of Dentistry, Qassim University, Buraydah, Qassim, Saudi Arabia.

Correspondence:

Abdullah Ali Alharbi, Dental Intern, College of dentistry, Qassim University, Buraydah, Qassim, Saudi Arabia Email; Abdul.alharbi502@gmail.com

Bangladesh Journal of Medical Science Vol. 23 Special Issue 2024

DOI: https://doi.org/10.3329/bjms.v24i10.79179

IAC morphological variations using CBCT in a Saudi Arabian population. By analysing these variations, dental and maxillofacial professionals can optimize their surgical strategies to mitigate risks and improve patient outcomes. Furthermore, this study contributes to the existing body of knowledge on the significance of CBCT inpreoperative planning for safe and effective dentalsurgeries [7].

METHODOLOGY

The study employed a cross-sectional, retrospective methodology to evaluate Cone Beam Computed Tomography (CBCT) scans to identify morphological variations in the inferior alveolar canal (IAC). Data collection took place in the Department of Oral Medicine and Radiology at theCollege of Dentistry, Al-Qassim University, Saudi Arabia. The study's ethical considerations were managed by obtaining approval from the Institutional Review Board with no 21-09-03, ensuring that all data was collected and used in compliance with ethical guidelines. The sample consisted of 1006 CBCT scans, chosen randomly from the department's archive. The sampling technique involved random selection of CBCTscans from patients who met the inclusion criteria: at least 5 years old, with no medical abnormalitiessuch as tumours, cysts, or cleft lip/palate. Scans with technical issues or processing flaws wereexcluded due to compromised quality.

Data collection involved two trained observers who independently examined the CBCT images to identify variations in the IAC. The morphological variations examined included bifid mandibular canals, trifid mandibular canals, and double mandibular canals. The observers recorded their findings in a data sheet, noting canal type (Type I,Type II, Type III), direction (upward or downward), and bilateral presence. To ensure reliability and validity, the study employed a double-observer approach, where two experts reviewed the scans independently to minimize errors and bias. Any discrepancies between the observers' findings were resolved through discussion and consensus.

Data analysis involved calculating descriptive statistics for the variables, including mean, standard deviation, and percentages. Chi-square tests were used to examine associations between different variables, such as gender, age group, andcanal type, with a significance level of $p < 0.05$ indicating statistical significance.

RESULTS

The study's demographic results (Table 1) reveal that out of a total of 1,006 participants, males comprised the majority with 621 (61.7%), while females accounted for 385 (38.3%) (Figure 1). In terms of age distribution, the largest group was 18-34 years, with 574 individuals (57.1%). The 35-54 age group represented 39% (392 participants), and the smallest group, 55-75 years, comprised only 4% (40 participants) (Figure 2). Regarding

variation status, 807 participants (80.22%) were classified as having an "absence" of a specific condition or variation, whereas 199 (19.78%) were classified as having the "presence" of a specific condition or variation (Figure 1).

Table 1: Distribution of demographiccharacteristics of the study participants

Variable		n	%
Gender	Male	621	61.7
	Female	385	38.3
Age	18-34 Years	574	57.1
	35-54 Years	392	39
	55-75 Years	40	4
Variation Status	Absence	807	80.22
	Presence	199	19.78

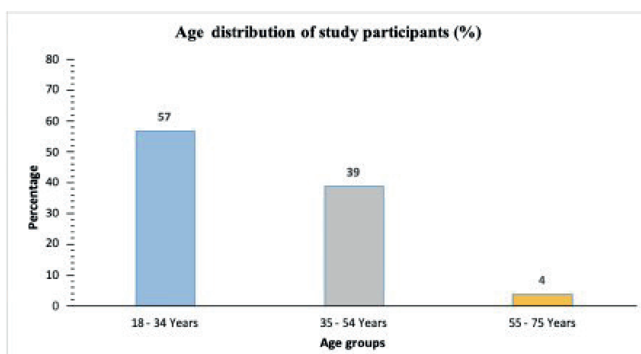

Figure 1: Gender distribution of study participants

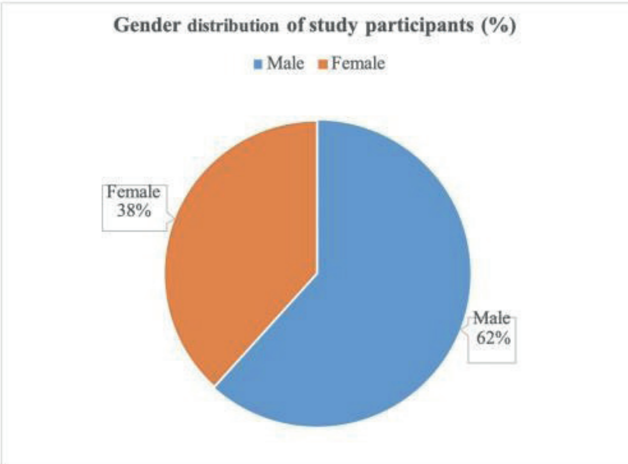

Figure 2: Age distribution of study participants

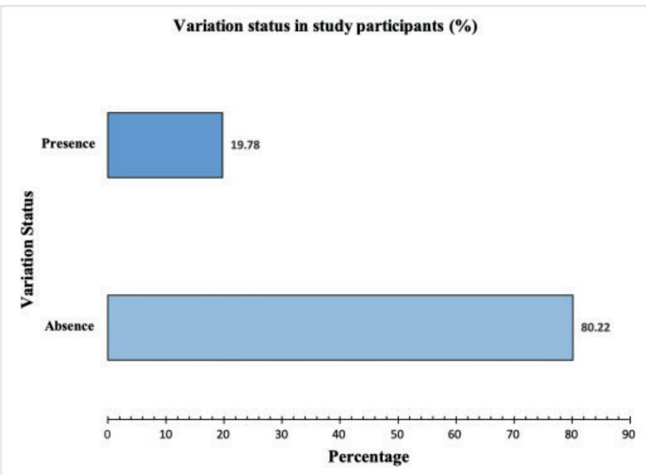

Figure 3. Variation status in study participants

Table 2 examines the association between gender and the variation status among 1,006 participants. Of the 807 individuals with an "absence" of a specific condition, 59.6% were male (481), while 40.4% were female (326). Conversely, among the 199 individuals with a "presence" of the condition, 70.4% were male (140), and 29.6% were female (59). The chi-square value of 7.806, with a p-value of 0.005, indicates a statistically significant association between gender and variation status, suggesting that males are more likely to exhibit thecondition in question. Figure 4 illustrates the relationship between gender and variation status, highlighting that males show a higher prevalence of the condition compared to females.

Table 2: Association between variation status and gender

Variati on Status	Gender				Total	Chi-square Value	p value
	Male		Female				
	n	%	n	%			
Absence	481	59.6	326	40.4	**807**	7.806	.005*
Presence	140	70.4	59	29.6	**199**		
Total	**621**	**61.73**	**385**	**38.27**	**1006**		

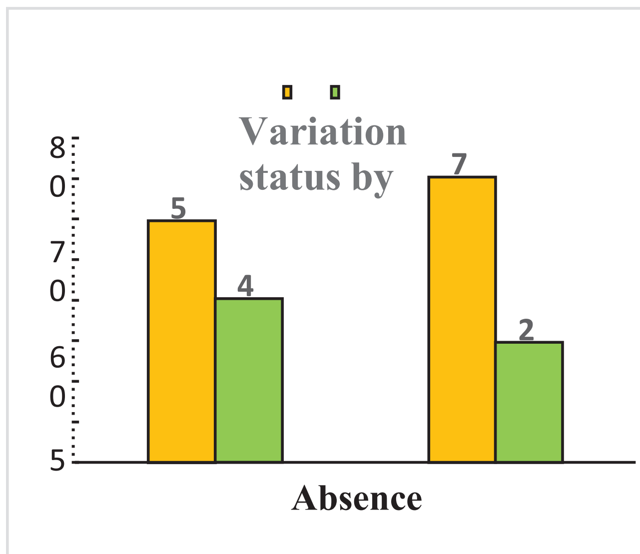

Figure 4. Variation status by gender

Table 3 shows the distribution of canal types among 199 study participants with a specific variation. The majority of these participantsbelong to Type II (Figure 7), which accounts for 35.2% (70 individuals), followed by Type I at 32.2% (64 individuals) (Figure 6), and Type III at 23.6% (47 individuals) (Figure 8,9). Type V is less common, representing 8.5% (17 individuals) (Figure 11-15), while Type IV is the rarest, with only 0.5% (1 individual) (Figure 10).

Table 3. Distribution of canal type of study participants with presence of variation

Canaltype	n	%
TypeI	64	32.2
TypeII	70	35.2
TypeIII	47	23.6
TypeIV	1	0.5
TypeV	17	8.5
Total	**199**	**100**

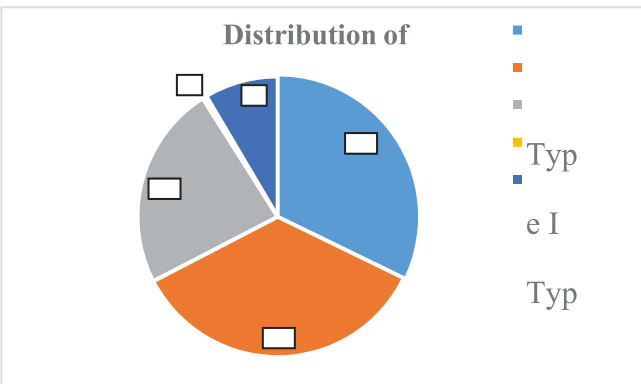

Figure 5: Distribution of canal type

Figure 5 illustrates the distribution of canal types among study participants, showing that Type II is the most common, followed by Type I and Type III, while Types IV and V are significantly less prevalent.

Table 4 explores the relationship between canal type, direction, and gender, revealing intriguing patterns across various classifications. Among Type I (Retromolar), the "Curved" direction shows a clear male majority, with 68.3% males and 31.7% females, while the "Vertical" direction is female-dominant at 75%. Type II (Dental) demonstrates similar trends, with males constituting 66% in the "2nd molar region" and 73.9% in the "3rd molar region." For Type III, focusing on "Forward without confluence," there is a strong male presence, particularly in the "2nd molar region," with 83.3% males, and in the "3rd molar region,"

Table 4. Association between Direction and Gender

Canal Type	Classification	Direction	Gender				Total	pvalue
			Male(140)		Female (59)			
			n	%	n	%		
TypeI	Retromolar	Curved	41	68.3	19	31.7	60	
		Vertical	1	25	3	75	4	
TypeII	Dental	2nd molarregion	31	66	16	34	47	
		3rd molar regio n	17	73.9	6	26.1	23	0.193
TypeIII	Forward without confluence	2nd molar regio n	15	83.3	3	16.7	18	
		3rd molar regio n	7	100	0	0	7	
		Angleof the mand ible	0	0	1	100	1	
		2nd molar regio n	8	66.7	4	33.3	12	
		3rd molar	3	50	3	50	6	
	Forward with confluence	One forward canal & one bifid (dent al)	2	100	0	0	2	
		Retromolar	0	0	1	100	1	
TypeIV	Buccolingual	Left	1	100	0	0	1	
	Trifid(A)	*	1	100	0	0	1	
	Trifid(B)	Right (Retr omolar dental)	5	100	0	0	5	
TypeV	Trifid(C)	Two access ory (DC) (DC) bifid (DC)	7	77.8	2	22.2	9	
	Trifid(D)	Two access ories (DC)	1	50	1	50	2	

with a 100% male representation. The "Angle of the mandible," however, has only females.

The "Forward with confluence" category shows aneven distribution between genders at 50% each, indicating a balanced representation. Type IV (Buccolingual) has only male participants,suggesting a specific directional pattern. Type V, comprising various Trifid classifications, reveals a mix of gender distributions. "Trifid (A)" and "Trifid (B)" are entirely male, while "Trifid (C)" has a majority of males at 77.8%, and "Trifid (D)" has an equal split between males and females.

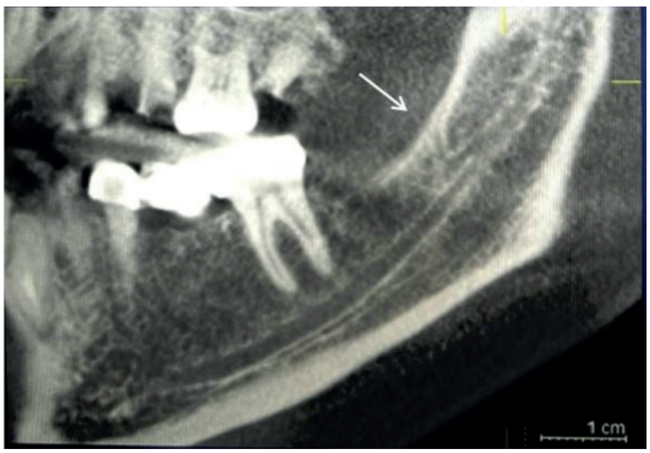

Figure 6: Type I (Bifid Retromolar Canal)

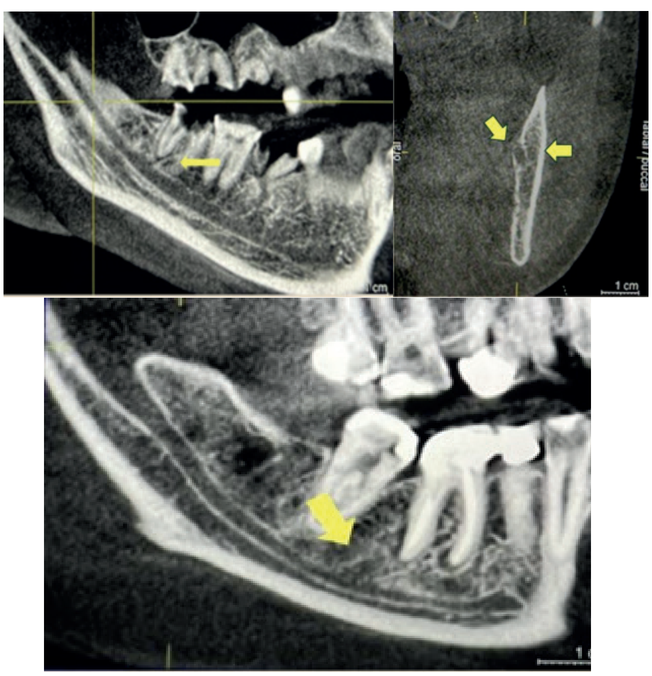

Figure 7: Type II (Bifid Dental Canal)

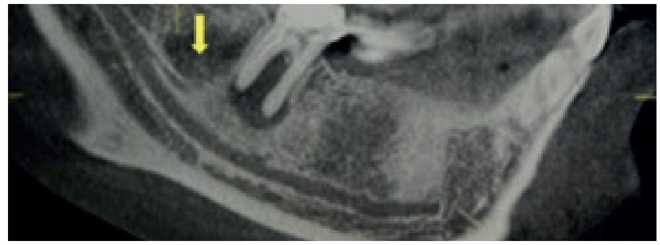

Figure 8: Type III (Bifid Forward canal) B-with confluence

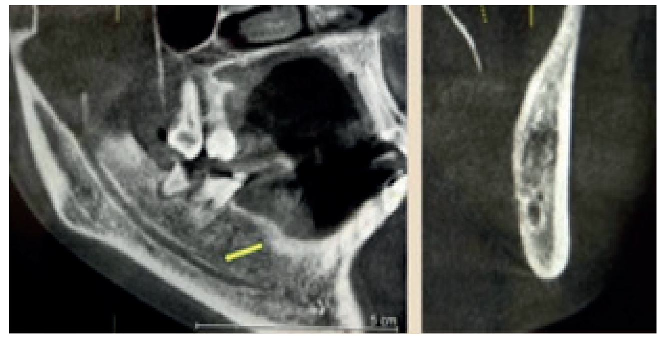

Figure 9: Type III: Bifid Forward Canal (Bifid with confluence)

Figure 10: Type IV: Buccolingual Canals; Bifid Lingual

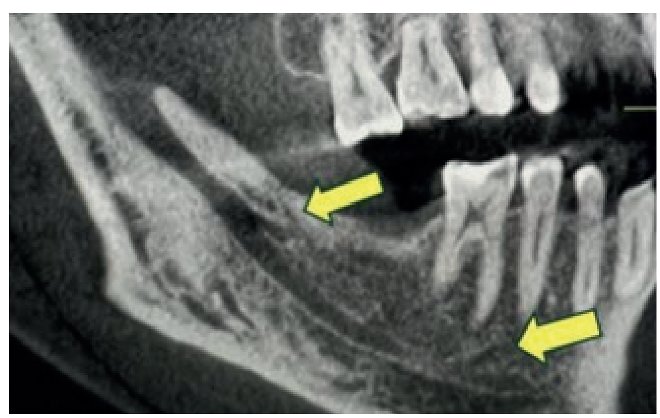

Figure 11: Type V: Trifid Canal; Two accessory canals (retromolar-dental)

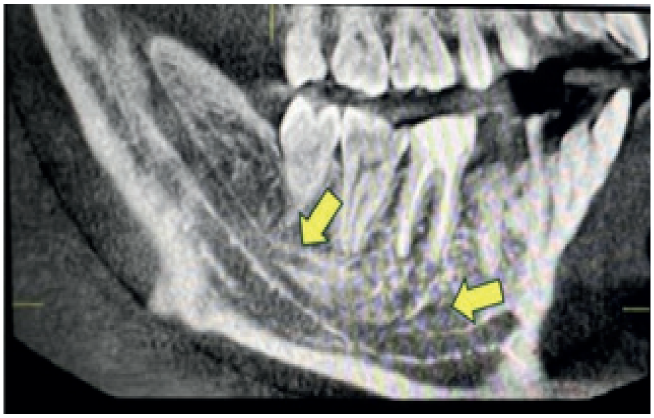

Figure 12: **Type V: Trifid Canal; Two accessory canals of ONE dental and ONE forward**

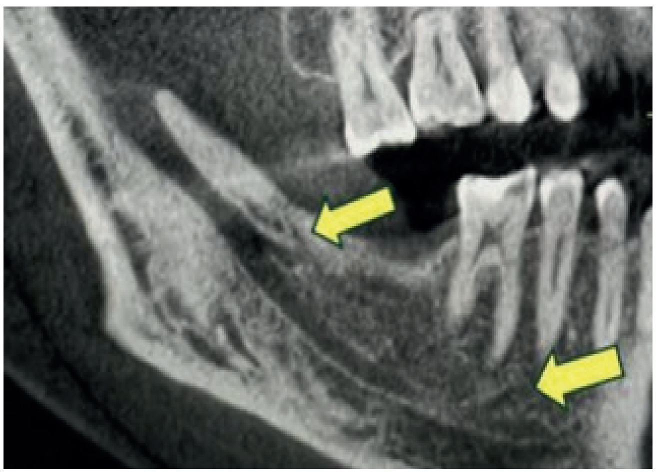

Figure 13: **Type V (Trifid canal); Two accessory canals (retromolar-dental)**

Figure 14: **Type V(Trifid Canal);Two accessory canals of ONE dental and ONE forward**

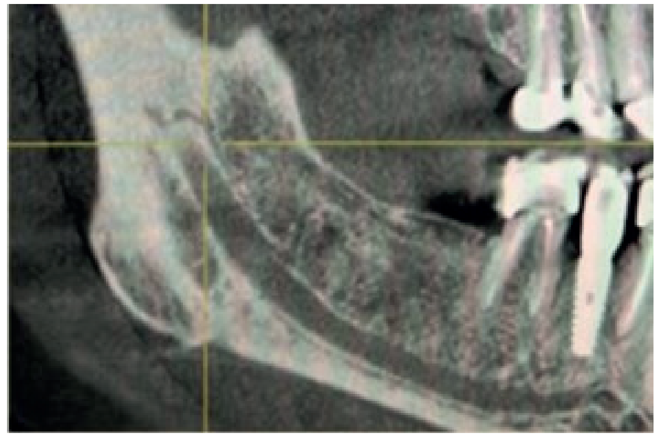

Figure 15: **Type V(Trifid Canal)Two accessory canals (retromolar) With two mandibular foramina**

DISCUSSION

The current study's findings provide valuable insights into the prevalence and characteristics of morphological variations in the inferior alveolar canal (IAC) in a Saudi Arabian population, with a specific focus on gender-based trends. The study's observation that males have a higher prevalence ofIAC variations (70.4% vs. 29.6% for females) is consistent with other studies focusing on anatomical variations in the jaw region. For instance, a study by Beam CR et al. also noted a higher incidence of IAC variations in males compared to females [8]. This trend could be due to inherent differences in bone density andstructural anatomy, often attributed to hormonal orgenetic factors.

Regarding canal types, the study revealed that Type II (bifid mandibular canals) was the most common, accounting for 35.2% of cases. This aligns with studies by Luangchana et al., which found that bifid canals are among the most frequent IAC variations detected through CBCT [9]. Another study by Misbah et al. highlighted the clinical significance of bifid canals in terms of surgical complications during dental and maxillofacial procedures. Type I and Type III,following in prevalence, indicate the common patterns clinicians should be aware of during preoperative planning [10]. This observation supports findings from studies like those by Motamedi MH et al., who also identified Type I asone of the frequently encountered IAC configurations in their research [11].

The study's exploration of canal direction and gender showed that in Type I (Retromolar), the "Curved" direction had a significant male representation, while the "Vertical" direction had more females. These results are supported by studies such as the one by Sanchis et al., which noted similar patterns in gender distribution basedon canal direction [12]. This gender-based variation in direction could be due to differential development patterns between males and females. In Type II (Dental), the prevalence of variations inthe 2nd and 3rd molar regions among males alignswith studies like those by Claeys and Wackens, where similar trends were observed [13]. Thisspecific focus on canal direction and its correlation with gender underlines the need for careful surgical planning to avoid complications like nerve damage.

The existing studies support the notion that understanding IAC variations, especially their types and gender-based trends, is crucial for safe and effective surgical outcomes. Studies like those by Wani et al. emphasize the role of CBCT in preoperative planning to detect these variations and minimize risks during procedures [14]. The current study's results contribute to this body of knowledge, reinforcing the importance of CBCT in dental and maxillofacial surgery and its role in enhancing patient safety.

CONCLUSION

The findings revealed that 19.78% of participants exhibited some form of IAC variation, with a significant gender-based difference, as 70.4% were male and 29.6% were female. The most common canal type was Type II (bifid mandibular canals), followed by Type I and Type III, suggesting that these configurations require particular attention during surgical planning. Additionally, the study identified specific gender-based patterns in canal direction, with males exhibiting a higher prevalence in certain canal types and regions. These results underscore the critical role of CBCT in preoperative planning for dental and maxillofacial surgery, allowingclinicians to identify potential risks and tailor theirsurgical approach to minimize complications. The study's conclusions highlight the importance of detailed anatomical assessment to enhance patient safety and improve surgical outcomes.

Ethical approval

Study approval was acquired from the Dental Research Institutional Review Committee on 10thFebruary 2022 (No 21-09-03) at the dental schoolof Qassim University, KSA.

Authors contribution

AA: Literature search SS, Collected data, analyzeddata, and prepared tables. Write up

SHK: Conceived, designed, and supervised the study, prepared tables, derived results, and carriedout the final editing of the manuscript. Both authors have critically reviewed and approved thefinal draft and are responsible for the content and similarity index of the manuscript.

REFERENCES

1. Issa J, Olszewski R, Dyszkiewicz-Konwińska M. The effectiveness of semi-automated and fully automatic segmentation for inferior alveolar canal localization on CBCT scans: A systematic review. International journal of environmental research and public health. 2022 Jan 4;19(1):560.
2. Chen JC, Lin LM, Geist JR, Chen JY, Chen CH, Chen YK. A retrospective comparison of the location and diameter of the inferior alveolar canal at the mental foramen and length of the anterior loop between American and Taiwanese cohorts using CBCT. Surgical and Radiologic Anatomy. 2013 Jan;35:11-8.
3. Mirbeigi S, Kazemipoor M, Khojastepour L. Evaluation of the course of the inferior alveolarcanal: the first CBCT study in an Iranian population. Polish journal of radiology. 2016;81:338.
4. Al Timimi AHU, Hameed Al Khafaji TG, Oglah Albaaj FS, Hasan HA, Alam MK. Identification of gender by radiographic analysis of mental foramen in a sample of Iraqi patients. Bangladesh J Med Sci. 2022;21(1):79-83
5. Nair UP, Yazdi MH, Nayar GM, Parry H, Katkar RA, Nair MK. Configuration of the inferior alveolar canal as detected by cone beam computed tomography. Journal of Conservative Dentistry and Endodontics. 2013Nov 1;16(6):518-21.
6. ChAudhAry ML, Anchalia S, Sharma V. Evaluation of inferior alveolar canal and its variations using cone beam CT-scan. IJARS. 2018 Jan;7(1):15-20.
7. Sahman H, Sisman Y. Anterior loop of the inferior alveolar canal: a cone-beam computerized tomography study of 494 cases. Journal of Oral Implantology. 2016 Aug 1;42(4):333-6.
8. Beam CR, Kaneshiro C, Jang JY, Reynolds CA, Pedersen NL, Gatz M. Differences between women and men in incidence rates of dementia and Alzheimer's disease. Journal of Alzheimer's disease. 2018 Jan 1;64(4):1077- 83.
9. Luangchana P, Pornprasertsuk-Damrongsri S, Kitisubkanchana J, Wongchuensoontorn C. The retromolar canal and its variations: Classification using cone beam computed tomography. Quintessence International. 2018Jan 1;49(1).
10. Mizbah K, Gerlach N, Maal TJ, Bergé SJ, Meijer GJ. The clinical relevance of bifid and trifid mandibular canals. Oral andmaxillofacial surgery. 2012 Mar;16:147-51.
11. Jain TK, Jha R, Tiwari A, Agrawal N, Mali S,Sinha A, Bagde H, Singh R. A Comparative Study to Evaluate the Anesthetic Efficacy of Buffered Versus Non-buffered 2% Lidocaine During Inferior Alveolar Nerve Block. Cureus. 2022 Nov 24;14(11):e31855.
12. Sanchis JM, Peñarrocha M, Soler F. Bifid mandibular canal. Journal of oral and maxillofacial surgery. 2003 Apr 1;61(4):422-4.
13. Sujon MK, Alam MK, Rahman SA, Mohd Noor SNF. Third Molar Impactions Prevalenceand Pattern Among Adults Using 5923 Digital Orthopantomogram. Bangladesh J Med Sci. 2022;21(3):717-29.
14. Ishak MH, Zhun OC, Shaari R, et al. Panoramic radiography in evaluating the relationship of mandibular canal and impacted third molars in comparison with cone-beam computed tomography. Mymensingh Medical Journal: MMJ. 2014 Oct;23(4):781-786.