Head & Face Medicine

RESEARCH

Open Access

Comparison of cone beam-computed and micro-computed tomography data for measuring facial canal dehiscence

Mert Ocak[1*], Ferhat Geneci[2], Bilge İpek Torun[2], Mehmet Fatih Şentürk[3] and Emine Şebnem Kurşun Çakmak[4]

Abstract

Background Selecting the correct imaging technique for critical anatomical structures is essential in descriptive studies and for supporting clinical applications. Facial canal dehiscence poses a significant risk for iatrogenic facial nerve injuries during middle ear surgeries. Accurate imaging is critical for surgical planning and minimizing complications. Detection of facial canal openings in the clinic is performed using imaging methods such as high-resolution computed tomography (HRCT). Studies have shown that the sensitivity of this method is approximately 66%. A high-resolution, 3D imaging method was used to measure the sensitivity of HRCT in the most accurate way.

Aims/Objectives This study aimed to compare two radiological methods for measuring facial canal dehiscence. Specifically, we compared cone-beam computed tomography (CBCT) with high-resolution micro-computed tomography (micro-CT).

Materials and methods Thirty-six temporal bone specimens without external defects were used. The specimens were scanned using both CBCT and micro-CT. The presence of facial canal dehiscence in the tympanic segment of the facial nerve (FN) was evaluated. A paired sample t-test was used for statistical analysis, with significance set at $p < 0.05$.

Results Facial canal dehiscence was detected in 10 bones on micro-CT images, while 26 bones appeared intact. In contrast, CBCT images showed dehiscence in 25 bones, with 11 bones intact. Additionally, the mean dehiscence width was 3.469 mm (range: 1.577–8.921 mm) in micro-CT images, compared to 1.279 mm (range: 0.670–9.354 mm) in CBCT images. In the 10 bones where dehiscence was identified by both methods, the average width of the dehiscence measured 5.347 mm (range: 1.840–9.354 mm) in the CBCT images. The difference in measurements between CBCT and micro-CT was statistically significant ($p < 0.05$).

Conclusions and significance The low resolution of CBCT was insufficient for visualizing the thin bony tissue lining the facial canal. These findings suggest that the frequency of facial canal dehiscence measured in preoperative CBCT images may be overestimated compared to actual anatomical conditions. These findings provide critical insights for preoperative evaluation and surgical planning in middle ear procedures.

Keywords Facial nerve, Facial canal dehiscence, Micro-CT, CBCT

*Correspondence:
Mert Ocak
mocak@ankara.edu.tr

Full list of author information is available at the end of the article

Introduction

The facial nerve (FN), an important anatomical structure in the head and neck region, has a long course within the temporal bone and plays a critical role in facial expression, speech, and eye closure. A dehiscence in the bony canal within the middle ear can render the facial nerve vulnerable to injury during middle ear surgery, posing significant risks to both functional and aesthetic outcomes for patients. Iatrogenic facial nerve injury is a well-recognized complication with potentially severe consequences, including permanent facial paralysis and incomplete eye closure leading to vision loss. FN injuries during middle ear surgeries are relatively common, and the incidence is significantly higher in patients with facial canal dehiscence [1]. The integrity of the bony canal surrounding the FN is critical for protecting the nerve from the destructive effects of cholesteatoma and injury during surgery [2].

Facial canal dehiscence can be congenital, due to ossification deficiencies, or it may develop as a result of diseases such as cholesteatoma. Ossification or calcification, plays a critical role in the development of these conditions. Abnormal ossification patterns can result in structural changes in the facial canal, making it more prone to dehiscence and increasing the risk of iatrogenic facial nerve injuries. A cartilage frame forms around the facial nerve in the fetus at the 16th week. This cartilage structure covering the facial nerve begins to ossify in the 24th week and turn into a bone canal covering this nerve. This development of the facial canal continues after birth. 83% of the development of the facial canal is completed in intrauterine life, and the remaining 17% is completed after birth. Anomalies in intrauterine life are mostly effective in developmental disorders of the facial canal [3–5]. Congenital hearing loss, Turner syndrome, Treacher-Collin syndrome, congenital stapes fixation, congenital aural atresia, CHARGE syndrome, congenital microtia, Klinefelter syndrome, trisomy 13, Antley-Bixler Syndrome and DiGeorge syndrome are some of the diseases that cause intrauterine anomalies that affect bone development in the facial canal [6]. Cholesteatoma is a cystic lesion containing squamous epithelium that forms in the middle ear. As cystic and tumorous structures enlarge, they damage surrounding structures in the middle ear, potentially leading to complications such as FN palsy. The dehiscence of the facial canal and the erosion of the middle ear ossicles share the same pathogenesis, explaining the frequent co-occurrence of these two events. A previous study suggested that facial canal dehiscence is relatively common even in the absence of middle ear disease [7].

Iatrogenic nerve injuries during surgery can cause significant problems for both patients and clinicians, including irreversible damage and the potential for malpractice lawsuits. Injuries to the FN can result in facial deformities and complications, and also social or psychological distress for patients. Sharp et al. [8] identified the FN as one of the most frequently injured nerves during head and neck surgeries, particularly in the inner ear and cheek. They reported a 13.1% incidence of FN injury after inner ear operations. Yetiser's study reported that one in ten patients has a dehiscence in the facial canal, making the FN more prone to injury during middle ear surgeries. In this study conducted on 144 patients who had middle ear surgery for various reasons, it was determined that 16 patients had dehiscence in the facial canal. Facial nerve paralysis occurred in 4 of these 16 patients, which resolved within two weeks after surgery [9]. Similarly, Lin et al. [10] found that the incidence of facial canal dehiscence increases to 33% in patients with cholesteatoma. In this study, which included 117 patients who underwent tympanoplasty, it was observed that 87.2% of the dehiscences were only in the tympanic segment, 7.7% were only in the vertical segment, and 5.1% were in both tympanic and vertical segments. Although clinical studies report facial canal dehiscence rates of up to 33%, anatomical studies show rates as high as 57%, likely due to the more detailed examination methods used. Likewise, histological studies tend to report higher rates than clinical studies [7]. Facial canal dehiscence is usually acquired, but it can also be congenital, and it is most commonly located in the tympanic segment [11].

Accurate preoperative assessment of dehiscence is essential to minimize surgical risks and improve patient outcomes. The detection and measurement of facial canal dehiscence are typically performed using imaging modalities like high-resolution computed tomography (HRCT). Several studies comparing HRCT data with intraoperative findings have demonstrated a sensitivity of 66% for HRCT [12–14]. In a 2019 study, Johnson et al. [1] found that cholesteatoma (42%) and chronic suppurative otitis media (33%) were the most common causes of facial canal dehiscence. In the same study, HRCT detected facial canal dehiscence in 34% of cases, with the authors attributing the low observation rate to the thinness of the FN in the tympanic region, which makes it difficult to visualize. Yu et al. [15] analyzed HRCT images from 76 ears in 72 patients with chronic otitis media and cholesteatoma. Their study showed that the HRCT findings were consistent with surgical observations in 67 of the 76 ears.

In this study, we aimed to assess the reliability of cone-beam computed tomography (CBCT) for measuring facial canal dehiscence, using high-resolution micro-computed tomography (micro-CT) as the reference standard. Although micro-CT is limited to small specimens and is not applicable in clinical practice, its exceptionally high resolution makes it ideal for the detailed

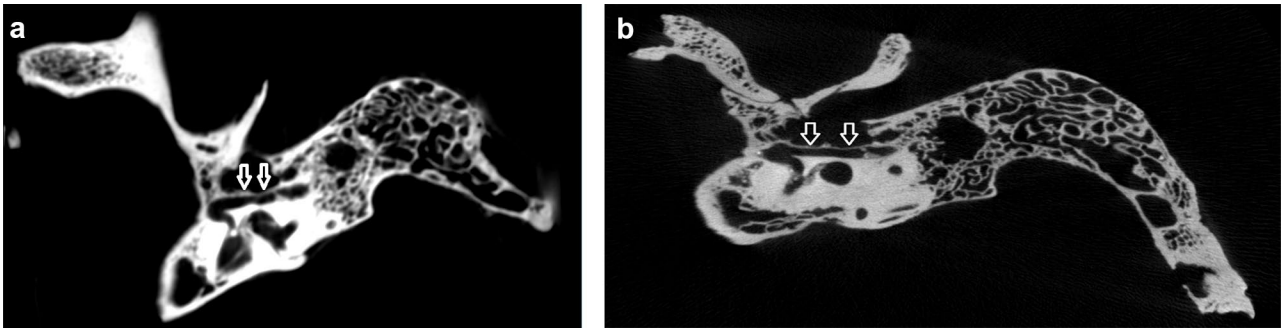

Fig. 1 (**a**) CBCT view of the facial canal with intact bone structure. (Arrows show the bone structure covering the facial canal). (**b**) Micro-computed tomography image of the facial canal with intact bone structure of the same sample. (Arrows show the bone structure lining the facial canal)

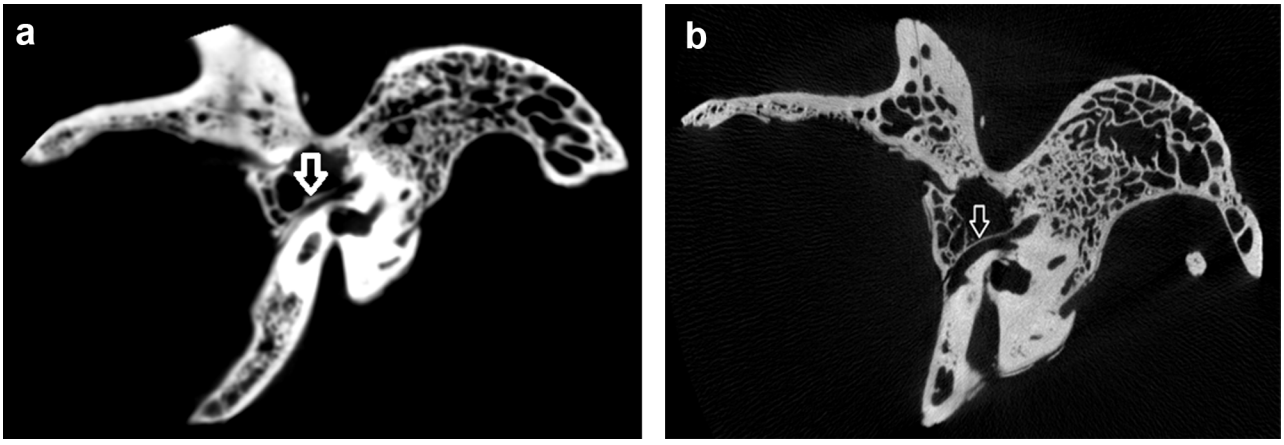

Fig. 2 (**a**) CBCT view of the facial canal with dehiscence (Arrow show the bone structure covering the facial canal). (**b**) Micro-computed tomography image of the facial canal with intact bone structure of the same sample. (Arrow show the bone structure lining the facial canal)

examination of anatomical structures in the temporal bone [16]. The null hypothesis (H_0) of this study was that there would be no significant difference between CBCT and micro-CT in the identification rates and measurements of facial canal dehiscence. By exploring the strengths and limitations of these imaging modalities, we aim to provide clinicians with practical insights for improving surgical planning and reducing the risk of complications.

Materials and methods

Bones

The study was approved by the Ethics Committee of Ankara Yıldırım Beyazıt University (Approval number: 08/891). A total of 36 dry temporal bones (18 right, 18 left) were obtained from the Anatomy Department. The inclusion criteria were that the bones were free from any physical damage. The presence of facial canal dehiscence in the tympanic segment of the facial nerve (FN) was assessed using both micro-computed tomography (Micro-CT) and cone-beam computed tomography (CBCT) (Figs. 1 and 2).

Micro-CT

All bone specimens were positioned in the Micro-CT device (SkyScan 1275, Kontich, Belgium) according to their anatomical orientation in the human body and scanned in this position. All measurements were performed in the axial plane. The scanning parameters were as follows: 1-mm aluminum filter, 80 keV, 125 µA, 10 µm resolution, 47 ms exposure time, 180° rotation, and a rotation step of 0.400°. Three-dimensional reconstruction was performed using NRecon reconstruction software (version 1.6.9.4; Bruker Micro-CT). Measurements were made using CTAn software on reconstructed 2D images (version 1.17.7.2; Bruker Micro-CT), and three-dimensional images were generated with CTVol software (version 2.3). The separations detected in the two-dimensional cross-sectional images were confirmed as present or absent with 3D reconstructions. However, distance measurements were made on two-dimensional sections due to the software constraints (Fig. 3).

CBCT

Bone specimens were positioned in the CBCT device (Planmeca Promax 3D Max, Helsinki, Finland) in their anatomical orientation and scanned under the following

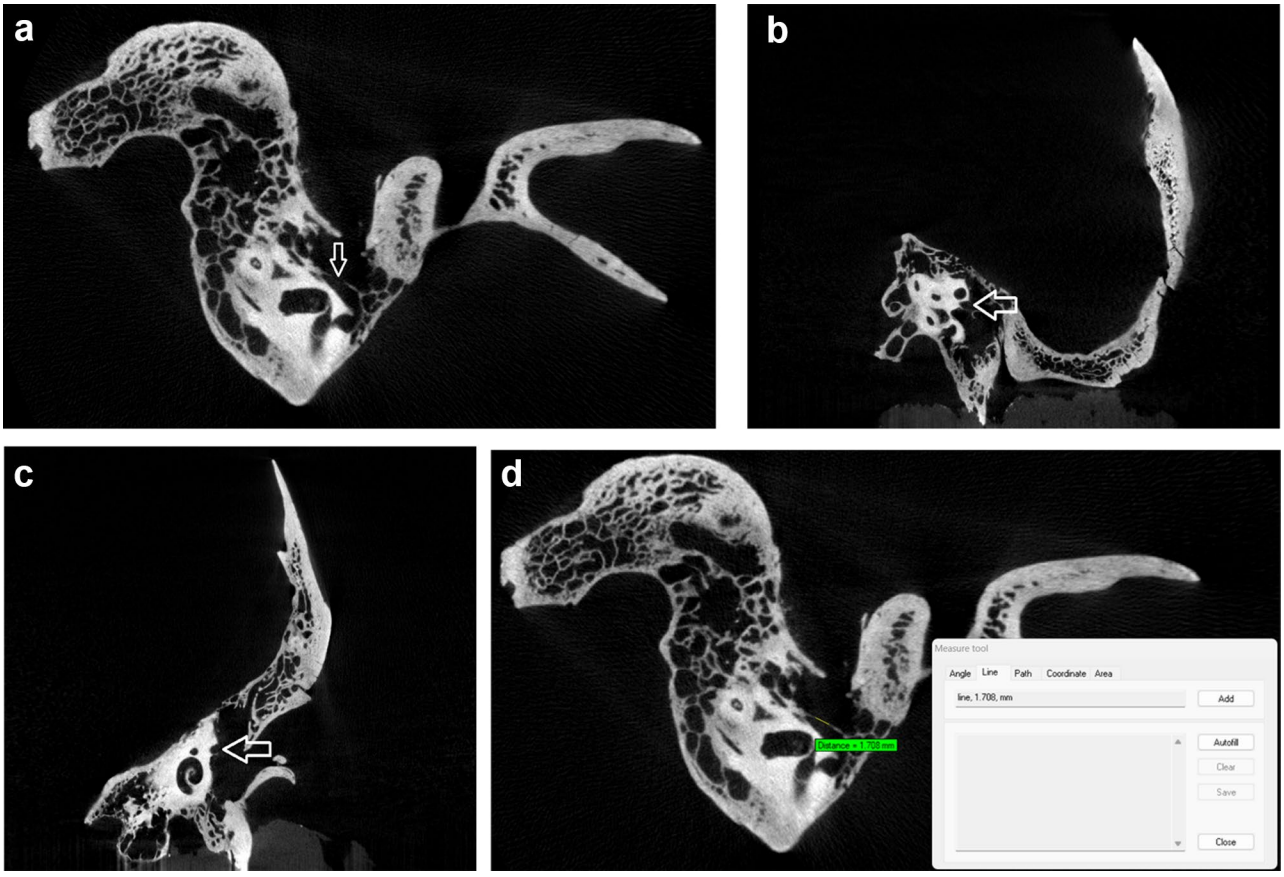

Fig. 3 (**a**) Visualization of the dehiscence in the fascial canal in the axial axis. (The arrow indicates dehiscence in the fascial canal) (**b**) Visualization of the dehiscence in the fascial canal in the coronal axis. (The arrow indicates dehiscence in the fascial canal) (**c**) Visualization of the dehiscence in the fascial canal in the sagittal axis. (The arrow indicates dehiscence in the fascial canal) (**d**) Measurement of the opening in the fascial canal in the axial axis

parameters: 96 kVp, 10 mA, 575 × 575 mm image field, and a section thickness of 0.4 mm.

Statistical analysis

The data were analyzed using SPSS statistical software (v.23; IBM Corp., Armonk, NY). The normality of the data distribution was assessed using the Shapiro-Wilk test, and the homogeneity of variances was evaluated using Levene's test. Both tests confirmed that the assumptions for performing the paired-sample t-test were met. Statistical analysis was conducted using paired-sample statistics, with statistical significance set at $p < 0.05$. A paired-samples t-test was used to assess whether the differences in the arithmetic means between the two groups were statistically significant.

All measurements were performed by a single, blinded researcher to avoid bias. Repeated measurements were conducted one week apart to ensure consistency and minimize variability caused by external factors. The reliability of repeated measurements was assessed using the intra-class correlation coefficient (ICC), and results from both repeated and independent measurements were statistically compared.

Results

The intra-class correlation coefficient (ICC) for the consistency of the researcher's measurements ranged from 0.94 to 0.97, indicating high reliability. Overall, the consistency of all measurements fell within the confidence interval.

Comparative data on facial canal dehiscence measurements are presented in Table 1. Through micro-CT analysis, the average length of the facial canal was measured as 11.303 mm (range: 8.387–13.809 mm). It was observed that 28% (10 bones) of the specimens had facial canal dehiscence, while 72% (26 bones) did not. The dehiscences were small areas located above the bony canal, with an average width of 3.469 mm (range: 1.577–8.921 mm).

In the CBCT analysis, the average length of the facial canal was measured as 12.884 mm (range: 11.168–13.993 mm). Dehiscence was absent in 31% (11 bones) of the specimens, whereas 69% (25 bones) showed dehiscence. In most cases, the bony structure of the facial canal was not clearly visible. The mean width of the facial canal dehiscence was 1.279 mm (range: 0.670–9.354 mm).

Table 1 Comparison of Micro-CT and CBCT measurements for facial canal dehiscence

Measurements	Micro-CT		CBCT		*P* Value
	Mean ± SD (*n*)	Range (Min-Max)	Mean ± SD (*n*)	Range (Min-Max)	
Facial canal length (mm)	11.303 ± 1.428 (36)	8.387–13.809	12.884 ± 0.667 (36)	11.168–13.993	*< 0.001**
Dehiscence width (mm)	3.469 ± 3.229 (10)	1.577–8.921	1.279 ± 2.850 (25)	0.670–9.354	*0.056*

* $P < 0.001$. SD, standard deviation; mm, milimeters; min, minimum; max, maximum; micro-CT, microcomputed tomography; CBCT, cone beam computed tomography

All bones with dehiscence detected via micro-CT also showed dehiscence in the CBCT images. However, in 15 bones where micro-CT showed an intact facial canal, CBCT indicated missing bony tissue, resulting in false-positive findings for facial canal dehiscence on CBCT. Conversely, none of the specimens with dehiscence detected by micro-CT appeared intact in the CBCT images, meaning that no false negatives were observed in the CBCT images when compared to micro-CT for detecting dehiscence.

Regarding dehiscence measurements, CBCT consistently reported larger dehiscence widths compared to micro-CT. However, the average facial canal length was smaller in CBCT. This discrepancy occurred because bones with no dehiscence on micro-CT (recorded as 0) were found to show dehiscence on CBCT, and these measurements were included in the average calculation. The average width of dehiscence was 2.862 mm (range: 0.80–8.12 mm) in the 15 samples where dehiscence was not detected on micro-CT but was observed on CBCT.

In the 10 bones where dehiscence was detected using both methods, the average width was 3.469 mm (range: 1.577–8.921 mm) on micro-CT and 5.347 mm (range: 1.840–9.354 mm) on CBCT. A paired-samples t-test showed a positive correlation of 0.620 between these measurements, but the statistical significance was greater than 0.05 ($p = 0.056$).

Discussion

The aim of this study was to assess the reliability of CBCT in measuring facial canal dehiscence by comparing it with high-resolution micro-CT. Our findings revealed that, although CBCT identified a higher rate of facial canal dehiscence compared to micro-CT, it also produced a significant number of false positives. This discrepancy is likely due to the lower resolution of CBCT, which hinders the accurate visualization of the thin bony tissue covering the facial canal.

In this study, a voxel size of 400 µm was selected for CBCT imaging to reflect routine clinical settings, where this resolution is commonly used for anatomical evaluations. It is acknowledged that utilizing a higher-definition mode (75 µm) would likely yield results more comparable to micro-CT due to enhanced visualization of fine structures. However, such high-resolution modes are not routinely employed in clinical settings, limiting their applicability for widespread use. Additionally, 400 µm aligns with the typical diagnostic capabilities of CBCT in preoperative imaging, ensuring clinical relevance.

The rate of facial canal dehiscence reported in anatomical studies ranges from 29 to 74%, while in studies conducted with a microscope during surgery, this rate varies between 6% and 43%. In 2019, Johnson et al. [1] compared radiological images with intraoperative findings in 70 patients, evaluating HRCT data. The study reported a false positive rate of 30% and a false negative rate of 65% for HRCT. In our study, all discrepancies in CBCT data were due to false positives in the diagnose of dehiscence, with no false-negative findings observed. This can be attributed to the thinness of the bony structure covering the facial canal, which was often not discernible on CBCT images, leading to false detections of dehiscence. In the absence of bony coverings, HRCT images are unlikely to falsely depict the presence of bone. We hypothesize that false-negative results in other studies may be due to limitations in the evaluation of radiological data.

Kharel et al. [7] reported a facial canal dehiscence rate of 12.7% based on HRCT images from 158 patients. Furthermore, when comparing clinical and histological studies, it has been noted that the incidence of dehiscence is higher in histological studies, potentially due to the destruction of the bony tissue covering the facial canal during sample preparation. The rates of facial canal dehiscence observed in our study for both micro-CT and CBCT were higher than those reported in previous studies. False positives in histological studies may result from the disruption of the bony tissue during sectioning, yet there is still the possibility of false positives in radiological images, even in the absence of bone damage. A comparative study between histological and radiological data could provide valuable insights into the margin of error associated with each method.

In a study by Arias-Marzan et al. [11], preoperative CT data from 57 patients scheduled for surgery were compared with intraoperative findings. They reported that facial canal dehiscence was detected at a significantly higher rate during surgery than on preoperative CT images, indicating the presence of false negatives in CT assessments. The detection rate of dehiscence on preoperative CT images was reported to be 50%, likely due to the thinness of the bony canal covering the facial nerve, making it challenging to assess the canal's integrity on CT images. Similarly, in our study, the thinness of the

bony tissue covering the facial canal complicated accurate evaluation using conventional radiological images. However, unlike their findings, all errors in our study were false positives, where intact bony canals were misinterpreted as dehiscent on CBCT images.

Hernandez-Trejo et al. [17] identified facial canal dehiscence in 51% of cases based on CT images of 184 temporal bones from patients without a history of temporal bone or middle ear disease. Although their findings were not confirmed by surgical data, the observation of facial canal dehiscence in a significant proportion of individuals without middle ear pathology may explain the high positive detection rate observed in our study. Previous research has demonstrated that micro-CT is highly effective in imaging complex structures within the middle ear due to its superior resolution. Similarly, our study confirms that micro-CT is more reliable than clinical CT for imaging this region. Although micro-CT is not typically used in clinical practice, we believe that it can significantly contribute to the anatomical literature on bone and tissue samples [18].

Conventional radiology offers several advantages in diagnosing clinical pathologies such as cholesteatoma. However, interpretation is challenging with traditional radiology due to its reliance on a single plane. Consequently, clinical diagnosis often requires the combined evaluation of comparative radiographs and clinical data. In a retrospective study involving 580 cholesteatoma patients (2003–2023), Popescu et al. [19] reported that diffusion-weighted MRI (DWI) demonstrated higher diagnostic accuracy for detecting recurrences not visible on standard CT scans compared to traditional imaging techniques. The study emphasized the importance of developing standard imaging protocols and highlighted that incorporating DWI with conventional methods could facilitate early detection, improve surgical outcomes, and reduce postoperative complications. Our findings suggest that integrating advanced techniques such as 3D imaging and MRI may enhance diagnostic and treatment success. Specifically, 3D reconstructions provide a more comprehensive assessment of facial canal dehiscence compared to two-dimensional (2D) sections. Unlike 2D images, which are constrained by slice orientation and thickness, 3D imaging enables multi-angle visualization of the entire facial canal, minimizing the risk of overlooking small or irregular dehiscences.

Despite the contributions of this study to understanding the anatomy of the facial canal, it has several limitations. First, the use of cadaveric temporal bones may not fully reflect in vivo conditions, as the absence of soft tissue can influence the visualization of dehiscence. Additionally, while micro-CT provides high-resolution images, its application is limited to research due to its small sample size and high radiation dose, making it impractical for clinical use. The higher dehiscence rate observed in CBCT images can likely be attributed to its lower resolution, resulting in potential false positives, as observed in our findings. Clinically, it is important to interpret preoperative CT findings cautiously, as CBCT may overestimate the presence of facial canal dehiscence. Therefore, intraoperative confirmation is essential to avoid unnecessary surgical risks when dehiscence is suspected.

Conclusion

This study demonstrated a statistically significant difference ($p < 0.05$) between CBCT and micro-CT in measuring facial canal dehiscence, rejecting the null hypothesis. CBCT was found to overestimate the presence of dehiscence due to its lower resolution, leading to false-positive results. These findings highlight the limitations of CBCT in accurately visualizing thin bony structures and emphasize the superiority of micro-CT for detailed anatomical evaluation. Clinicians should interpret CBCT findings with caution, as they may not reflect actual anatomical conditions. Intraoperative verification is recommended to ensure accurate clinical decisions.

Acknowledgements
None.

Author contributions
M.O and F.G contributed to the conception, design, data acquisition, analysis and interpretation, and drafted and critically revised the manuscript. B.İ.T and E.Ş.K.Ç contributed to the analysis and data interpretation. F.Ş. contributed to the conception and data interpretation and drafted the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

Funding
None.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethical approval
Ankara Yıldırım Beyazıt University Non-Invasive Ethics Committee (2021-36).

Competing interests
The authors declare no competing interests.

Author details
[1]Faculty of Dentistry, Department of Anatomy, Ankara University, Yenimahalle, Ankara 06560, Turkey
[2]Faculty of Medicine, Department of Anatomy, Ankara Yıldırım Beyazıt University, Ankara, Turkey
[3]Faculty of Dentistry, Department of Oral, Dental, and Maxillofacial Surgery, Ankara Yıldırım Beyazıt University, Ankara, Turkey
[4]Faculty of Dentistry, Deparment of Radiology, Ankara Yıldırım Beyazıt University, Ankara, Turkey

Received: 21 October 2024 / Accepted: 3 February 2025
Published online: 28 April 2025

References

1. Johnson P, Mur T, Vogel R, Roehm PC. Percutaneous threshold of facial nerve stimulation predicts facial canal dehiscence. Neurodiagnostic J. 2019;59:91–103.
2. Şahin MM, Çayonu M, Kayalı Dinç AS, Boynuegri S, Barut FE, Eryilmaz A. Cautionary findings for the presence of facial canal dehiscence during cholesteatoma surgery. Ear Nose Throat J. 2020;99(5):327–30.
3. Beger O, Erdoğan O, Kara E, Vayisoglu Y, Gorur K, İsmi O, et al. Morphometric properties of the facial canal in children: a retrospective computed tomography study. Int J Pediatr Otorhinolaryngol. 2019;124:59–67. https://doi.org/10.1016/j.ijporl.2019.05.039.
4. Talas DÜ, Beger O, Koç T, Hamzaoglu V, Ozalp H, Mavruk M, et al. Morphometric properties of the facial nerve in fetal temporal bones. Int J Pediatr Otorhinolaryngol. 2019;116:7–14. https://doi.org/10.1016/j.ijporl.2018.10.012.
5. Asghar A, Priya A, Narayan RK, Patra A, Walocha J, Skrzat J. An evaluation of morphometry and dehiscence of facial canal: a systematic review and meta–analysis of observational studies. Surg Radiol Anat. 2024;46:1501–16.
6. Talas DÜ, Beger O, Koç T, Hamzaoğlu V, Özalp H, Mavruk M, et al. Morphometric properties of the facial nerve in fetal temporal bones. Int J Pediatr Otorhinolaryngol. 2019;116:7–14.
7. Kharel B, Shreepaili A, Tripathi P, Neupane Y, Gurung U, Pradhananga RB, et al. Relationship between ossicular chain erosion and facial canal dehiscence in chronic otitis media squamous. JIOM Nepal. 2020;42(2):1–4.
8. Sharp E, Roberts M, Żurada-Zielińska A, Zurada A, Gielecki J, Tubbs RS, et al. The most commonly injured nerves during surgery: a comprehensive review. Clin Anat. 2021;34(2):244–62.
9. Yetiser S. The dehiscent facial nerve canal. Int J Otolaryngol. 2012;679708.
10. Lin JC, Ho KY, Kuo RW, Wang LF, Chai CY, Tsai SM. Incidence of facial nerve dehiscence after surgery for middle ear cholesteatoma. Otolaryngol Head Neck Surg. 2004;131(4):452–6.
11. Arias-Marzan F, Lucas-Carmona G, Pacheco-Coronel ER, Perez-Lorensu PJ, Jimenez-Sosa A, Perez-Pinero B. Facial canal dehiscence in patients with cholesteatoma: concordance between intraoperative imaging, computed tomography, and neurophysiological findings. Eur Arch Otorhinolaryngol. 2019;276:1915–20.
12. Fuse T, Tada Y, Aoyagi M, Sugai Y. CT imaging of facial canal dehiscence and semicircular canal fistula: comparison with surgical findings. J Comput Assist Tomogr. 1996;20(2):221–4.
13. Rogha M, Hashemi SM, Mokhtarinejad F, Eshaghian A, Dadgostar A. Comparison of preoperative temporal bone CT findings with intraoperative findings in patients with cholesteatoma. Iran J Otorhinolaryngol. 2014;26(1):7–12.
14. Kanotra S, Gupta R, Gupta N, Sharma R, Gupta S, Kotwal S. Correlation between high-resolution computed tomography temporal bone findings and intraoperative findings in patients with cholesteatoma. Indian J Otol. 2015;21(4):280.
15. Yu Z, Wang Z, Yang B, Han D, Zhang L. Preoperative CT scan of the tympanic facial nerve canal in tympanomastoid surgery. Acta Otolaryngol. 2011;131:774–8.
16. Geneci, F, Ocak M. Examination of sinus tympani, subtympanic sinus, and facial sinus with MicroCT. Clinical Anatomy. 2023; 36(3), 414–419. https://doi.org/10.1002/ca.23968
17. Hernandez-Trejo AF, Cuellar-Calderón KP, Trevino-Gonzalez JL, Yamamoto-Ramos M, Campos-Coy MA, Quiroga-Garza A, et al. Prevalence of facial canal dehiscence and other bone defects by computed tomography. Eur Arch Otorhinolaryngol. 2020;277:2681–6.
18. Geneci F, Uzuner MB, Bilecenoğlu B, Torun Bİ, Orhan K, Ocak M. Examination of inner ear structures: a micro-CT study. Acta Otolaryngol. 2022;142(1):1–5.
19. Popescu C, Vărut RM, Puticiu M, Belghiru VI, Banicioiu M, Rotaru LT, et al. Comprehensive management of cholesteatoma in otitis media: diagnostic challenges, imaging advances, and surgical outcome. J Clin Med. 2024;13:6791.

Publisher's note