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Periapical Bone Density and Microstructural Assessment in Teeth with Type-1 Palatogingival Groove: A Retrospective Preliminary CBCT Study

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Abstract

Objectives

This retrospective study aimed to assess the impact of Type-1 palatogingival grooves (PG) on periapical bone microstructure and radiodensity in maxillary lateral incisors using fractal dimension (FD) and mean gray value analyses on cone-beam computed tomography (CBCT) images.

Material and methods

Twenty-eight CBCT records presenting unilateral Type-1 PG in maxillary lateral incisors were included. Contralateral non-grooved lateral incisors served as internal controls. FD (trabecular complexity) and mean gray value (bone density) were measured within a standardized 10 x 10 pixel Region of Interest (ROI) located in the periapical alveolar bone (2 mm coronal and 2 mm palatal to the root apex) using ImageJ software. Intra-examiner reliability was assessed via the Intraclass Correlation Coefficient (ICC). A post-hoc power analysis was performed.

Results

High intra-examiner reliability was achieved (ICC = 0.906). No statistically significant difference was observed in FD values between the PG (1.01 +/- 0.05) and control groups (1.01 +/- 0.06) (Z = -0.46, p = 0.649). The mean gray value was 76.03 +/- 13.65 in grooved regions and 70.66 +/- 9.54 in control regions; this difference did not reach statistical significance (t = 1.95, df = 27, p = 0.062; 95% CI: -0.29 to 11.02). No gender-based differences were detected (p > 0.05).

Conclusion

Type-1 PGs do not significantly alter the trabecular micro-architecture or bone density of periapical alveolar bone compared to healthy contralateral teeth. Although a subtle, non-significant elevation in gray values was observed in grooved sites–potentially indicating early subclinical osseous adaptation–Type-1 grooves demonstrate periapical bone stability. Extended studies including complex groove types (Types 2 and 3) are required to further elucidate these findings.

Introductıon

PG is a developmental anomaly; although its etiology is not fully known, it has been reported to result from the infolding of Hertwig's epithelial root sheath and the inner enamel epithelium (Fig. 1). Consequently, irregular grooves generally occur on the palatal surfaces of maxillary anterior incisors [1]. These groove areas act as a reservoir for bacterial accumulation and pathogenic microorganisms, consequently leading to complications in the form of endodontic, periodontal, or combined lesions [2].

PG was categorized into three different types by Gu et al. [3]: Type 1 is a short groove (not exceeding the coronal middle third of the root); Type 2 is a long groove (exceeding the coronal middle third) but is shallow and has a normal root-canal configuration; and Type 3 is a long groove (exceeding the coronal middle third) that is deep and has a complex root-canal configuration. Particularly in severe cases progressing to the root apex, combined lesions and more advanced treatment approaches may be required.

Treatment approaches vary according to the types. In Type 1, conservative approaches such as odontoplasty and sealing the groove with biocompatible materials (glass ionomer, MTA) are applied. In Type 2, the long but shallow groove, periodontal regenerative procedures are applied accompanied by endodontic treatment. In Type 3, representing the most severe cases, treatments such as guided tissue regeneration and replantation may be required. Efficient results can be obtained with early initiation of treatment and a multidisciplinary approach [4, 5].

To date, no radiomorphometric study has evaluated periapical bone microstructure and density specifically in maxillary lateral incisors with Type-1 PG. Therefore, this retrospective study aimed to compare periapical bone radiodensity and fractal dimension between teeth with Type-1 PG and their healthy contralateral controls using CBCT image analysis. The null hypothesis was that the presence of a Type-1 PG does not cause significant differences in periapical bone density or trabecular fractal complexity.

Materıals and methods

This retrospective study was conducted using CBCT records obtained from the archives of a university dental faculty. Approval for the study was obtained from the Institutional Ethics Committee (Decision no: 2025/10–19, Date: 17/10/2025). All procedures were performed in accordance with the Declaration of Helsinki. This observational studies has been written according to Preferred Reporting items for Observational studies in Endodontics (PROBE) 2023 guidelines.

Sample Selection CBCT data of a total of 28 individuals (13 males, 15 females) presenting with a unilateral PG in the maxillary lateral incisor were included in the study.

Inclusion criteria:

Clear visualization of the Type-1 PG on CBCT in maxillary lateral incisors.

Absence of a groove on the contralateral side in the same individual.

Maxillary lateral incisors being vital and periodontally healthy.

CBCT images belonging to individuals aged 18–65 years.

Exclusion criteria:

History of trauma.

Presence of pathological lesions.

Images containing artifacts.

History of extensive restoration or surgical intervention.

CBCT images were obtained using a CS 9600 imaging system (Carestream Dental, Atlanta, GA, USA). A voxel size ranging from 0.075 to 0.15 mm, tube current of 2–15 mA, tube voltage of 60–120 kVp, and scan times ranging from 5.5 to 40 s were used depending on the diagnostic requirements. Field of view (FOV) values ranged from 5 × 5 cm to 12 × 16 cm in all scans. The obtained CBCT sections were evaluated by an experienced oral and maxillofacial radiologist.

Morphometric measurements

Two regions were examined for each individual:

The alveolar bone region adjacent to the maxillary lateral incisor with Type-1 PG (grooved region).

The alveolar bone region adjacent to the symmetrical maxillary lateral incisor on the contralateral side in the same individual (control – non-grooved region).

The sections were examined three-dimensionally, and all measurements were performed in the sagittal plane. The region of interest was selected as the alveolar area extending 2 mm palatal and 2 mm coronal to the apex of the lateral incisor. The ROI size was standardized as 10 × 10 pixels in both groups. All analyses were performed by the same observer on the selected regions using ImageJ software (National Institutes of Health, Bethesda, MD, USA).

Evaluated parameters

Histogram analysis (gray level distribution of the ROI area). Fractal analysis (evaluation of the complexity level of the bone trabecular pattern). Measurements were performed independently by an experienced oral radiologist, and the average of the data was included in the analysis.

Reliability and Power analysis

To assess the intra-examiner reliability of the measurements, 15 subjects were randomly selected and re-evaluated by the same examiner at a different time point. The intraclass correlation coefficient (ICC) for the repeated measurements was calculated as 0.906, indicating excellent intra-examiner reliability. A

post-hoc power calculation using G*Power software (version 3.1.9.7) determined that with N = 28, alpha = 0.05, and an effect size of d = 0.46, the statistical power (1 - beta) was 0.58, supporting the preliminary pilot nature of this study.

Statistical analysis

All statistical evaluations were performed using SPSS Statistics 26.0 (IBM Corp., Armonk, NY, USA) software. The distribution of the data was analyzed using the Shapiro-Wilk test. FD values obtained from grooved and non-grooved regions, which did not show normal distribution, were compared using the Wilcoxon signed-rank test. The paired samples t-test was applied for gray value results showing normal distribution. For comparisons according to gender, the Mann-Whitney U test was used for fractal dimension, and the independent samples t-test was used for gray values. Data were presented as mean ± standard deviation or median (minimum–maximum). The statistical significance level was set at $p < 0.05$.

Results

A total of 28 individuals (15 females [53.6%] and 13 males [46.4%]) ranging in age from 18 to 50 years were included in the study. The mean age of the participants was calculated as 27.71 ± 9.36 years. FD and gray value measurements obtained from grooved and non-grooved regions were compared regionally and by gender (Fig. 2).

The mean FD was found to be 1.01 ± 0.05 (min: 0.93, max: 1.16) in grooved regions and 1.01 ± 0.06 (min: 0.86, max: 1.16) in non-grooved regions (Fig. 3). The Wilcoxon signed-rank test revealed no statistically significant difference between grooved and non-grooved FD values ($Z = -0.46$, $p = 0.65$). Although FD was higher in the non-grooved region in 13 measurements and in the grooved region in 15 measurements, this distribution did not reach the level of statistical significance.

In the gray value analysis, the mean gray value was calculated as 76.03 ± 13.65 (min: 54.05, max: 108.54) in grooved regions and 70.66 ± 9.54 (min: 53.19, max: 89.46) in non-grooved regions. The paired samples t-test showed that although the gray value was higher in grooved regions, this difference was not statistically significant ($t = 1.95$, $df = 27$, $p = 0.062$; 95% CI: −0.29–11.02) (Table 1).

In the comparison by gender, no significant difference was found between females and males in terms of FD values (Mann–Whitney $U = 91.00$, $p = 0.77$). No significant difference was detected between females and males regarding gray values ($p = 0.65$) (Table 2).

Discussion

Palatogingival groove is an anatomical anomaly that presents diagnostic challenges due to its hidden palatal location and variable clinical presentation. While severe grooves (Types 2 and 3) frequently precipitate combined endodontic-periodontal breakdowns, mild forms (Type 1) are often discovered

incidentally during routine 3D imaging. This study provides the first CBCT-based radiomorphometric investigation of periapical bone trabecular complexity and density associated specifically with Type-1 PGs.

The primary outcome of this investigation is that the null hypothesis was accepted: Type-1 PGs do not cause statistically significant changes in periapical bone fractal dimension ($p = 0.649$) or radiodensity ($p = 0.062$) compared to contralateral non-grooved controls.

A wide range of values exists for PG prevalence in the literature. A range between 0.9% and 4.9% has been reported, while a recent meta-analysis [6] calculated it as 1.5%. The reason for this wide range may stem from differences in study designs. Indeed, these analyses have been performed on extracted teeth, clinical examinations, and two-dimensional imaging techniques [5, 7]. Furthermore, different methods are used in PG diagnosis, such as SEM [8], micro-CT [3], and CBCT [9]. While diagnosis via clinical examination is very difficult, bone destruction also cannot be examined. Since extracted teeth are used in SEM analysis, the periodontal tissue status or apical pathology of the tooth in its natural environment (in vivo) cannot be analyzed. Two-dimensional methods remain weak in diagnosis due to inherent limitations.

According to histological and microscopic examinations, accessory canals in contact with the PG groove and bacterial colonies in the periodontium can cause pulp infection [10–12]. In fact, the starting point of our hypothesis is based on this scenario. This study investigated the effect of potential bacterial invasion, which may develop due to periodontal and accessory canal connections, on the periapical bone.

When categorized by alveolar bone destruction and PG classification, bone destruction was observed in 16% of Type 1 cases, 88.2% of Type 2 cases, and 100% of Type 3 cases [13]. Additionally, according to the mentioned study, a significant relationship exists between periapical pathology and PG grooves extending to the apex. A significant relationship was also found between periodontal destruction and the presence of periapical lesions. In other words, as bone destruction increases, bacterial invasion extending to the pulp via accessory canals may induce apical pathologies. Considering the tendency for such apical pathology and periodontal treatment needs to develop together, a multidisciplinary treatment approach is essential.

With FD analysis, it is possible to mathematically calculate how bone microstructure is affected by drugs, systemic diseases, or during the evaluation of pre-op bone site quality. Looking at FD studies performed on the mandible; Temur et al. [14] measured mandibular FD in patients with sickle cell disease and concluded that the disease negatively affects bone structure. In an analysis regarding drug use, Kaya and Koç [15] reported that although proton pump inhibitors do not significantly affect microstructure, they may lead to cortical erosion. Before the use of orthodontic temporary anchorage devices, safer regions in the jaws were investigated via FD and BD analysis, and it was stated that the palatal bone region at the level of the 1st premolar is a safer area [16]. Although no significant relationship was found between FD and Type-1 PGs in our study, the tendency for an increase in BD in

the apical bone of grooved teeth should not be ignored. This increase in sclerosis can be considered a bone defense reaction resulting from minimal inflammation-induced stimulation.

Limitations Although our study is the first to perform FD analysis on this type of anomaly, the inclusion of only Type 1 PG is a limitation. This is because periodontal bone destruction and apical pathology were more frequently encountered in other types in previous studies. However, conducting this study using CBCT, which excludes inherent artifacts such as superposition found in OPG, is a strength of this study.

Future Considerations Future studies with larger participation including Type 2 and Type 3 PG grooves can be conducted. Microstructure analysis can also be performed using pre- and post-treatment follow-up radiographs of PG grooves. However, using techniques such as apical radiography instead of high-dose CBCT for such follow-up procedures would be in accordance with the ALARA principle and for the patient's benefit.

Conclusion

Type-1 palatogingival grooves do not significantly alter periapical bone density or trabecular micro-architecture in periodontally healthy maxillary lateral incisors. The slight, non-significant elevation in bone gray values suggests a stable, non-destructive periapical environment. Type-1 grooves appear to carry a low risk for early periapical osseous breakdown.

Declarations

Ethics approval

This retrospective study was approved by the Van Yüzüncü Yıl University Non-Interventional Clinical Research Ethics Committee (Approval No. 34312; Date: 31 October 2025). All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its later amendments.

Consent to participate

This study was conducted following approval from the Van Yüzüncü Yıl University Non-Interventional Clinical Research Ethics Committee. As this was a retrospective CBCT-based study using anonymized data, no direct participant involvement occurred.

Consent for publication

Not applicable.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Titlepage: Periapical Bone Density and Microstructural Assessment in Teeth with Type-1 Palatogingival Groove: A Retrospective Preliminary CBCT Study

Running Title: Radiomorphometry of Palatogingival Groove

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References

1. Lee KW, Lee EC, Poon KY. Palato-gingival grooves in maxillary incisors. A possible predisposing factor to localised periodontal disease. Br Dent J. 1968;124(1):14–8.
2. Cho YD, Lee JE, Chung Y, Lee WC, Seol YJ, Lee YM, et al. Collaborative management of combined periodontal-endodontic lesions with a palatogingival groove: a case series. J Endod. 2017;43(2):332–7. 10.1016/j.joen.2016.10.003.
3. Gu YC. A micro-computed tomographic analysis of maxillary lateral incisors with radicular grooves. J Endod. 2011;37:789–92.
4. Attam K, Tiwary R, Talwar S, Lamba AK. Palatogingival groove: endodontic-periodontal management–case report. J Endod. 2010;36:1717–20.
5. Gaudex Y, Gandillot V, Fontanille I, et al. Palatal groove associated with periodontal lesions: a systematic review illustrated by a decisional tree for management. BMC Oral Health. 2024;24:1037.

6. González OL, Salas Orozco MF, Marín NP, et al. Prevalence of Palatal Grooves on Maxillary Anterior Teeth Using Cone-beam Computed Tomography: A Systematic Review and Meta-Analysis. J Endod. 2025 Jul;11:S0099. 2399(25)00396-6.*.
7. Kim HJ, Choi Y, Yu MK, et al. Recognition and management of palatogingival groove for tooth survival: a literature review. Restor Dent Endod. 2017;42:77–86.
8. Gao Z, Shi J, Wang Y, Gu F. Scanning electron microscopic investigation of maxillary lateral incisors with a radicular lingual groove. Oral Surg Oral Med Oral Pathol. 1989;68(4):462–6. https://doi.org/10.1016/0030-4220(89)90147-3.
9. Aljuailan A, Aljuailan R, Gaikwad R, Kolarkodi S, Alamri N. Prevalence of palatogingival groove affecting maxillary anterior teeth in Saudi subpopulation: a cone-beam computed tomographic study with literatüre review. Saudi Dent J. 2023;35(8):1039–47. https://doi.org/10.1016/j.sdentj.2023.09.002.
10. Tan X, Zhang L, Zhou W, Li Y, Ning J, Chen X, Huang D. Palatal radicular groove morphology of the maxillary incisors: a case series report. J Endod. 2017;43(5):827–33.
11. Peikoff MD, Perry JB, Chapnick LA. Endodontic failure attributable to a complex radicular lingual groove. J Endod. 1985;11(12):573–7. https://doi.org/10.1016/s0099-2399(85)80205-3.
12. Goon WW, Carpenter WM, Brace NM, Ahlfeld RJ. Complex facial radicular groove in a maxillary lateral incisor. J Endod. 1991;17(5):244–8. https://doi.org/10.1016/S0099-2399(06)81931-X.
13. Yildirim DP, Goker Kamali S. Prevalence of palatogingival groove and its association with periapical lesions and periodontal bone loss: a cone beam computed tomography study. BMC Oral Health. 2025;25(1):313. https://doi.org/10.1186/s12903-025-05676-1.
14. Temur KT, Magat G, Yılmaz M, Ozcan S. Evaluation of the effect of sickle cell disease on the mandibular bone of children and adolescents by image texture and radiomorphometric analysis. Oral Radiol. 2023;39(4):792–801.
15. Kaya S, Koç A. Is there an association between proton pump inhibitors and radiomorphometric parameters of the mandible? A preliminary study. Oral Radiol. 2022;38(4):586–93.
16. Kotan S, Koç A, Öner Talmaç AG. The current overview of the devices of temporary anchorage placed on the palatal bone: CBCT study. Odontology. 2024;112(4):1335–42.

Tables

Table 1 and 2 are available in the Supplementary Files section.

Figures

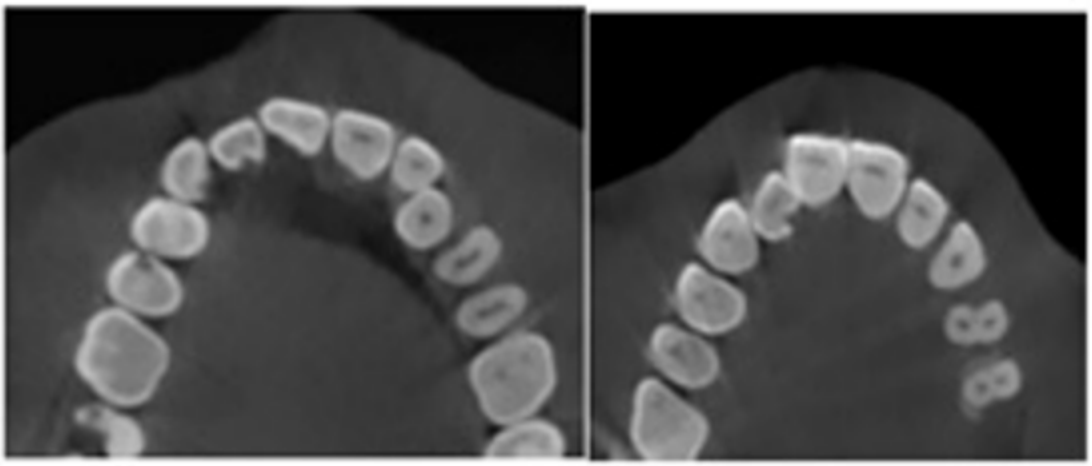


Fig. 1 Axial CBCT images showing a palatogingival groove on the maxillary right lateral incisor in two different patients

Figure 1

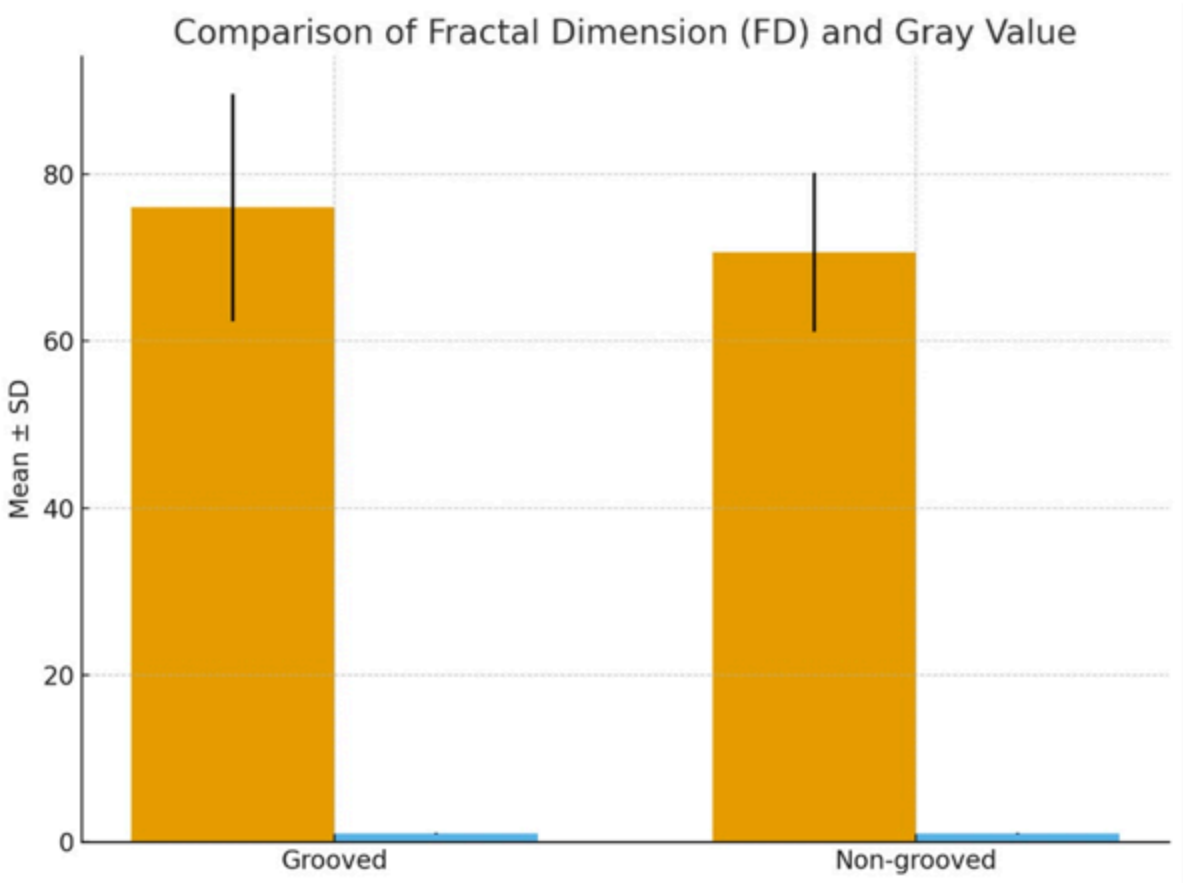


Fig. 2 Comparison of fractal dimension (FD) and gray values between grooved and non-grooved regions

Figure 2

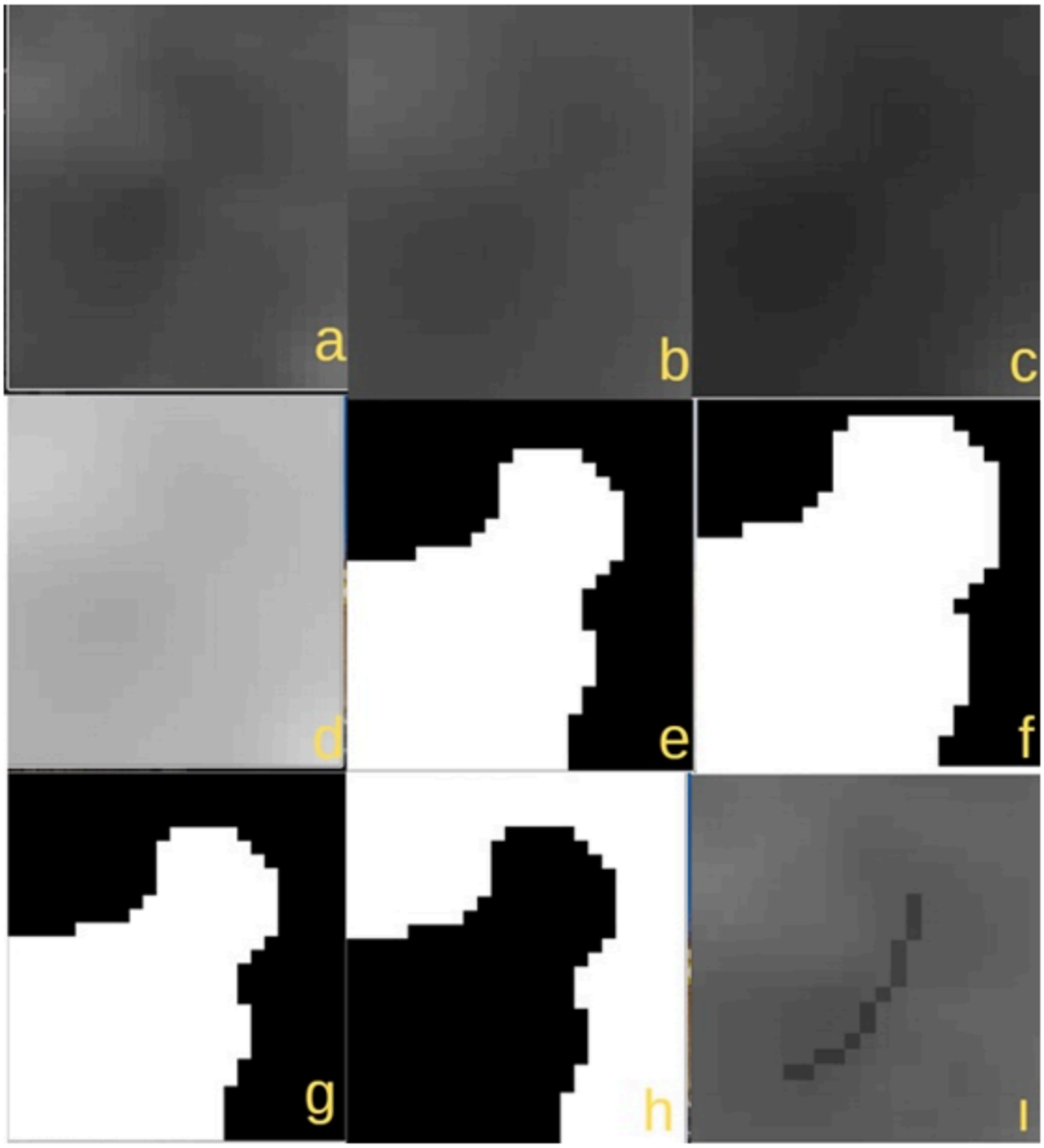


Fig. 3 Image preprocessing steps for fractal analysis: (a–d) grayscale processing procedures, (e–h) binarization and noise reduction, and (i) the final skeletonized trabecular structure

Figure 3

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1.png
- Table2.png