

A radiographic assessment of the prevalence of pulp stones in Australians

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Abstract

Background: Pulp stones are discrete calcified bodies found in the dental pulp. The aims of this study were to calculate the prevalence of pulp stones in young Australian adults using radiographs, and to report any associations between occurrence of pulp stones and sex, tooth type, dental arch, side and dental status.

Methods: From 217 undergraduate dental students, comprising 123 males and 94 females aged between 17-35 years, 3296 teeth were examined under 2x magnification on bitewing radiographs. Pulp stones were scored as present or absent, and associations with sex, tooth type, dental arch, side and dental status noted.

Results: Pulp stones were found in 100 (46.1 per cent) of the subjects and 333 (10.1 per cent) of the teeth examined. Occurrences were rare in premolars (0.4 per cent) but significantly higher in molars (19.7 per cent). Pulp stones were significantly more common in first molars than in second molars, and in maxillary first molars than in mandibular first molars. Carious and/or restored maxillary right first molars and maxillary left second molars displayed higher prevalences of pulp stones than unrestored and intact molars.

Conclusion: Pulp stones may provide useful forensic information when examining dental records to identify deceased persons.

Key words: Pulp tissue, calcification, dental arches, dental status.

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INTRODUCTION

Calcification can occur in the dental pulp as diffuse forms or as discrete calcified stones that may exist 'freely' in pulp tissue or become 'attached' to or 'embedded' into dentine.^{1,2} Pulp stones were histologically classified by Kronfeld¹ into 'true' or 'false' forms, the former containing irregular dentine

and the latter being degenerative pulp calcifications. Other studies have noted problems with the above classification and new histologic classifications have been proposed.²⁻⁴

Two types of calcified bodies in dental pulp have been mentioned by Moss-Salentijn and Klyvert;⁴ pulp stones being compact degenerative masses of calcified tissues and denticles possessing a central cavity filled with epithelial remnants surrounded peripherally by odontoblasts. Aetiological factors for pulp stone formation are not well understood, although, some factors that have been implicated in stone formation include pulp degeneration, inductive interactions between epithelium and pulp tissue,⁴ age,⁵ circulatory disturbances in pulp,⁶ orthodontic tooth movement,⁷ idiopathic factors⁸ and genetic predisposition.⁹ The formation of pulp stones has also been associated with long-standing irritants such as caries, deep fillings and chronic inflammation.¹ Recent literature still suggests that pulp stones are a feature of an irritated pulp, attempting to repair itself.¹⁰

Pulp stones have been noted to vary in number from one to 12 or more in a single tooth, their size varying from minute particles to large masses occluding the pulp cavity.² They have been reported to occur more often in coronal pulp² although they are also found in radicular pulp.³

The prevalence of pulp stones in teeth, based on radiographic examinations, has been reported to be around 20 to 25 per cent^{4,11-13} while histological examinations yield higher prevalences.⁵ Recently, Hamasha and Darwazeh¹¹ identified pulp stones in 51.4 per cent of Jordanian adults in a radiographic study.

The aims of this study were: to calculate the prevalence of pulp stones in young Australian adults using radiographs; to explore possible associations between pulp stones and sex, tooth type, dental arch, side and dental status; and to compare the results with published data.

MATERIALS AND METHODS

The study sample included 3296 teeth identified in bitewing radiographs of 217 undergraduate dental

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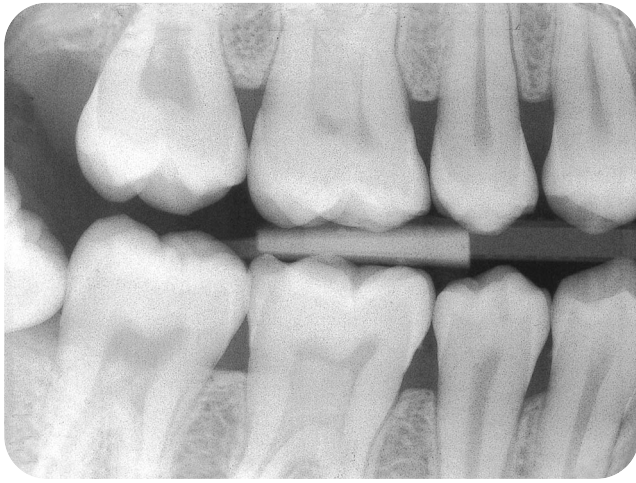


Fig 1. Pulp stones are present in all right taurodont molars; those in the first molars are occluding the pulp chambers.



Fig 2. Pulp stones are present in all left molars. The mandibular left second molar displays two pulp stones.



Fig 3. Pulp stones are present in the unrestored maxillary left first molar, and in the restored and carious mandibular left first molar.

students, comprising 123 (56.7 per cent) males and 94 (43.3 per cent) females aged between 17-35 years. The radiographs had been obtained previously as part of an unrelated study. Right and left bitewing radiographs, each including premolars and molars, were examined

under 2x magnification by one of the authors (SR) in a darkened room, using a light box with an even diffuse light source, and with peripheral light blocked out. Those with poor horizontal or vertical angulations, inadequate exposure or processing faults causing scoring difficulties were excluded from the study.

Pulp stones were identified as definite radiopaque masses inside the pulp chambers of the first and second premolars, and first and second molars. They were scored as present or absent, and the status of each tooth categorized as: (i) unrestored and intact, (ii) restored and intact, (iii) unrestored and carious, or (iv) restored and carious. The extent and size of restorations or caries, and the configuration of pulp stones, such as number, size and location in the pulp chamber were not detailed. Figures 1-3 provide examples of pulp stones in three of the subjects examined in this study.

Examiner reliability was calculated via replicate observations derived from double determination in all samples. Concordances for replicate identification of pulp stones and dental status were both 98.5 per cent, indicating that the scoring methods were highly reliable.

Chi-square analyses were used to compare the frequencies of occurrence of pulp stones between sexes, tooth types, dental arches, sides and dental status. Statistical significance for the analyses of the results was set at the 5 per cent probability level.

RESULTS

Prevalence of pulp stones and distribution between sexes

Pulp stones were found in 100 (46.1 per cent) subjects, which included 55 (44.7 per cent) of 123 males and 45 (47.9 per cent) of 94 females. The overall difference in distribution between the sexes was not statistically significant ($p > 0.05$). The overall occurrence of pulp stones in teeth in females (10.8 per cent of 1411 teeth) was similar to that in males (9.5 per cent of 1885 teeth), although a significant difference occurred in mandibular left second molars (17.2 per cent of 93 teeth in females compared with 8.3 per cent of 121 teeth in males) ($p < 0.05$). As there were no significant differences in pulp stone occurrence between antimeric teeth, data were pooled for sexes and sides, and are presented in Table 1.

Pulp stones and tooth types

Pulp stones were observed in 333 (10.1 per cent) of the 3296 teeth examined (Table 1). Pulp stones were found in only six (0.4 per cent) of the 1632 premolars and in 327 (19.7 per cent) of the 1664 molars, with the differences in occurrences being statistically significant ($p < 0.001$). Given the low frequency of occurrence of pulp stones observed in premolar teeth, further analyses were carried out for molar teeth only. The frequencies of pulp stones were higher in first molars than in second molars in each dental arch and when data for both arches were combined (27.5 per cent vs 11.9 per cent) ($p < 0.001$).

Table 1. Frequency of pulp stones in premolar and molar teeth of 217 young Australians, aged 17-35 years

| Tooth type | Maxilla No of teeth | | Mandible No of teeth | | Sum No of teeth | |
|------------|------------------------|--------------|-------------------------|-------------|--------------------|-------------|
| | Total | With PS | Total | With PS | Total | With PS |
| | N | n (%) | N | n (%) | N | n (%) |
| P1 | 402 | 2 (0.5) | 398 | 3 (0.8) | 800 | 5 (0.6) |
| P2 | 414 | 0 (0.0) | 418 | 1 (0.2) | 832 | 1 (0.1) |
| Sum P | 816 | 2 (0.2) | 816 | 4 (0.5) | 1632 | 6 (0.4)* |
| M1 | 425 | 146 (34.4)†‡ | 404 | 82 (20.3)†‡ | 829 | 228 (27.5)† |
| M2 | 418 | 55 (13.2)† | 417 | 44 (10.6)† | 835 | 99 (11.9)† |
| Sum M | 843 | 201 (23.8) | 821 | 126 (15.3) | 1664 | 327 (19.7)* |
| Total | 1659 | 203 (12.2) | 1637 | 130 (7.9) | 3296 | 333 (10.1) |

P=premolar; M=molar; PS=pulp stones

*Chi-square test significant for higher occurrences of pulp stones in molars than in premolars at $p<0.001$.

†Chi-square test statistically significant for higher occurrences of pulp stones in first molars than in second molars in each dental arch or when data for both arches were combined at $p<0.001$.

‡Chi-square test statistically significant for higher occurrences of pulp stones in maxillary first molars than in mandibular first molars at $p<0.001$.

Pulp stone occurrence and dental arches

Total occurrence of pulp stones was higher in maxillary molars (23.8 per cent) than in mandibular molars (15.3 per cent), but significant for first molar teeth only (34.4 per cent vs 20.3 per cent) ($p<0.001$) (Table 1).

In first molars, pulp stones were absent in both arches in around 61 per cent of the subjects and present in both arches in around 16 per cent of the subjects while around 18 per cent of the subjects displayed pulp stones in the maxilla only, and around 5 per cent of the subjects in the mandible only ($p<0.001$) (Table 2).

In second molars, pulp stones were absent in both arches in around 83 per cent of the subjects and present in both arches in around 7 per cent of the subjects while around 6 per cent of the subjects displayed pulp stones in the maxilla only, and around 4 per cent of the subjects in the mandible only ($p<0.001$).

Pulp stone occurrence and sides

In first molars, around 67 per cent of the subjects had no pulp stones on both sides and around 22 per cent of the subjects displayed bilateral occurrence of pulp stones. Fewer subjects displayed unilateral occurrence of stones; around 6 per cent on the left side only and around 5 per cent on the right side only ($p<0.001$) (Table 3).

In second molars, around 84 per cent of the subjects had no pulp stones on both sides and around 8 per cent of the subjects displayed symmetric distribution of pulp

stones. Fewer subjects displayed unilateral occurrence of pulp stones; around 5 per cent on the left side only and around 3 per cent on the right side only ($p<0.001$).

Pulp stones and dental status

Given that 1076 (64.7 per cent) of the 1664 molars examined were unrestored and intact (category i), data for categories ii, iii and iv were combined to reflect the sum of factors that could cause pulp irritation, and they are presented in Table 4. When compared with unrestored and intact molars, significantly higher occurrences of pulp stones were noted in restored and/or carious maxillary right first molars (28.8 per cent vs 41.7 per cent respectively), and maxillary left second molars (12.1 per cent vs 25.0 per cent respectively) ($p<0.05$). No significant differences were observed between dental status and pulp stone occurrence in other tooth groups.

DISCUSSION

Radiographic examinations are not likely to detect pulp stones less than 200µm in diameter,⁴ but radiographs are the only means of evaluating pulp stones non-invasively in clinical studies. Scoring difficulties in this study were encountered when pulp stones and carious lesions were very small or when radiographic images of alveolar bone and pulp stones were superimposed on a few occasions.

In our study, the size of pulp stones ranged from small particles to calcified bodies of large diameter that occluded most of the pulp chamber (Fig 1) and more

Table 2. Prevalence of pulp stones in maxillary and mandibular molar teeth

| Tooth type | No of subjects without PS in both arches | | No of subjects with PS in | |
|------------|--|---------------|---------------------------|-----------|
| | Maxilla only | Mandible only | Both arches | |
| | n (%) | n (%) | n (%) | n (%) |
| Right | | | | |
| M1* | 127 (62.3) | 37 (18.1) | 8 (3.9) | 32 (15.7) |
| M2* | 167 (84.8) | 12 (6.1) | 6 (3.0) | 12 (6.1) |
| Left | | | | |
| M1* | 117 (60.0) | 36 (18.5) | 11 (5.6) | 31 (15.9) |
| M2* | 169 (81.3) | 14 (6.7) | 9 (4.3) | 16 (7.7) |

*Chi-square test statistically significant for association between pulp stone occurrence and dental arches at $p<0.001$.

Table 3. Prevalence of pulp stones on left and right molar teeth

| Tooth type | No of subjects without PS on both sides | | No of subjects with PS on | |
|------------|---|-------------------------|---------------------------|---------------------|
| | n (%) | Left side only n (%) | Right side only n (%) | Both sides n (%) |
| Maxilla | | | | |
| M1* | 125 (59.2) | 13 (6.2) | 14 (6.6) | 59 (28.0) |
| M2* | 167 (82.7) | 10 (5.0) | 5 (2.5) | 20 (9.9) |
| Mandible | | | | |
| M1* | 146 (75.3) | 10 (5.2) | 7 (3.6) | 31 (16.0) |
| M2* | 173 (85.6) | 11 (5.4) | 5 (2.5) | 13 (6.4) |

*Chi-square test statistically significant for pulp stone occurrence and sides at $p < 0.001$.

than one pulp stone was identified in a single tooth on a few occasions (Fig 2), but quantitative measurements were not undertaken. The prevalence of pulp stones recorded in the subjects of this study was slightly lower than that reported recently in a Jordanian population.¹¹ The similar prevalence of pulp stones noted in males and females in this study agrees with some previous investigations^{3,6} and the finding that the occurrence of pulp stones tended to be higher in molars than in premolars is consistent with earlier reports.^{12,13}

The trend for a higher occurrence of pulp stones in first molars than in second molars is also in agreement with most previous investigations.^{13,14} Higher frequencies of pulp stones were noted in maxillary molars in this study, but similar frequencies in both the arches,^{3,4} or higher occurrences in mandibular teeth^{13,14} have also been reported.

A significant association between pulp stone occurrence in carious and/or restored teeth was noted in two tooth groups in this study, suggesting that chronic pulp irritation might lead to pulp stone formation, but these results need to be interpreted with caution given that they were derived from radiographic evidence only and that data for carious and restored teeth were pooled for analysis. A higher occurrence of pulp calcification has been noted in carious, unrestored teeth than in restored teeth,³ presumably because the pulps have some degree of chronic inflammation due to the caries and restorations.¹⁵ However, some studies¹² have failed to find any significant association between

pulp stone occurrence and the presence of caries or restorations. Protective pulpal responses to irritation, such as secondary dentine formation resulting in a decrease in the size of pulp chamber, and degenerative diffuse calcification might result in reduced ability to detect pulp stones in these teeth during radiographic examinations. The presence of pulp stones reported in very young teeth and developing tooth germs¹ indicates that pulpal pathology is unlikely to be the only aetiological factor for pulp stone formation.

The currently held clinical view is that pulp stones have no significance other than possibly causing difficulties during endodontic therapy, such as hindering canal location and negotiation.¹⁰ In forensic dentistry, radiographic matching of pulp stone configurations, along with other features recorded in dental records, may provide valuable information in the identification of deceased persons.

The limitations in this study included the method of sample selection, which included only young adults, so age-related changes could not be reported. A larger sample size would also enable a more detailed assessment of the relationship between pulp stone formation, caries and restorations. Detailed configurations of pulp stones were also not noted, nor were other factors that may cause pulpal irritation, such as tooth wear or periodontal conditions.

Further research is indicated to elucidate the aetiological factors involved in pulp stone formation. The use of pulp stones in forensic odontology might be

Table 4. Prevalence of pulp stones in molar teeth with different dental status

| Tooth type | Total | Dental status | | | | |
|------------------|-------|---------------|--|----------|--|--|
| | | Sum N | Unrestored and intact No of teeth with PS | | Restored and/or carious No of teeth with PS | |
| | | | n (%) | Sum N | n (%) | |
| Maxillary right | | | | | | |
| M1 | 214 | 118 | 34 (28.8)* | 96 | 40 (41.7)* | |
| M2 | 208 | 174 | 20 (11.5) | 34 | 5 (14.7) | |
| Maxillary left | | | | | | |
| M1 | 211 | 115 | 34 (29.6) | 96 | 38 (39.6) | |
| M2 | 210 | 174 | 21 (12.1)* | 36 | 9 (25.0)* | |
| Mandibular right | | | | | | |
| M1 | 205 | 96 | 19 (19.8) | 109 | 21 (19.3) | |
| M2 | 203 | 146 | 11 (7.5) | 57 | 7 (12.3) | |
| Mandibular left | | | | | | |
| M1 | 199 | 99 | 22 (22.2) | 100 | 20 (20.0) | |
| M2 | 214 | 154 | 17 (11.0) | 60 | 9 (15.0) | |
| Sum | 1664 | 1076 | 178 (16.5) | 588 | 149 (25.3) | |

*Chi-square test statistically significant for higher occurrence of pulp stones in restored and/or carious teeth than unrestored and intact teeth at $p < 0.05$.

enhanced if a relationship between age and pulp stone formation could be confirmed by longitudinal studies.

CONCLUSION

The features of pulp stones noted in this study may provide additional information about the dental morphological features of Australians. The development of a more discriminatory system to score the number and size of pulp stones observed on radiographs would further assist in forensic applications.

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