An investigation into the prevalence of vitamin D deficiency in a 19th century London population

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Introduction

The prevalence of rickets amongst urban children dramatically increased during the 19th century in England as a result of overcrowding, pollution, and poor diet.[1,2,3] However, the identification of this condition in the archaeological record is limited due to the remodelling of bone over time, the poor preservation of non-adult remains, and because clinical symptoms can occur in the absence of skeletal change.[4] Bioarchaeological identification of vitamin D deficiency (childhood rickets, residual rickets in adulthood, and osteomalacia) within post-medieval burial populations therefore likely does not represent the true prevalence of vitamin D deficiency during this period.

Vitamin D deficiency impacts the absorption of minerals such as calcium and phosphate, which clinical studies have shown can lead to a range of dental abnormalities.[5] Recent research has found significant differences in pulp chamber morphology in those with vitamin D deficiency, suggesting that radiographic analysis of teeth may be used as a screening tool to identify deficiency disease.[6]

This study investigates the prevalence of vitamin D deficiency in a 19th century London population, using radiographic assessment to identify adults with changes in pulp horn morphology associated with vitamin D deficiency during dental development.

Materials and Methods

Individuals were acquired for analysis from New Bunhill Fields, Southwark (1821-53) (N_{adult}=157, $N_{non\text{-}adult}$= 357).[7] Age estimation and sex assessment was performed by Museum of London Archaeology using standard methods.[8] A dental inventory of the adult population identified individuals with intact, non-friable, first permanent molars without significant dental wear or carious lesions. Palaeopathological analysis was performed on the adult population to assess for conditions associated with vitamin D deficiency (residual rickets, osteomalacia).[9,10]

30 adult individuals had suitable teeth and were selected for radiography (N_{male}=17, N_{female}=13). All teeth were radiographed at the University of Bradford's radiography laboratory using a Faxitron Cabinet X-ray System. The specimens were orientated as if a bitewing dental radiograph was being taken, from a lingual to buccal view in order to show the pulp chambers. All specimens were radiographed between 50-60kV for 90 seconds. The method established by D'Ortenzio et al. (2018) was followed to identify morphological changes in the pulp chamber (Fig.1).

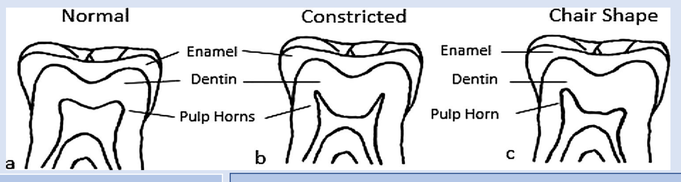


Fig. 1: Diagram of different pulp chamber shapes in a generic permanent molar. Source: D'Ortenzio et al. 2018:4

Results

- The adult individuals included in this study represent 19.1% of the excavated adult burial population from New Bunhill Fields.
- Only two of the 30 individuals had skeletal manifestations consistent with a diagnosis of residual rickets (abnormal bowing of the lower limbs) (1303, 1635).
- However, 28 individuals exhibited evidence for constricted (N=16) or chair-shaped (N=12) pulp chambers associated with vitamin D deficiency during pulp chamber formation.
- One adult male aged 18-25 years exhibited a normal pulp chamber.
- One further adult male aged 26-35 years exhibited an enlarged pulp chamber. This molar has an abnormal, poorly mineralised occlusal surface consistent with cuspal enamel hypoplasia (CEH) (Fig. 11).
- Two individuals (925, 1883) exhibited change in the first, second, and third molars.

Skeleton	Sex	Age (years)	Tooth (FDI)	X-ray
367	Male	36-45	46	Constricted
389	Male	36-45	36	Constricted
393	Female	36-45	46	Chair
467	Female	18-25	46	Chair
514	Male	36-45	36	Constricted
576	Female	18-25	46	Constricted
642	Female	18-25	26	Constricted
723	Male	18-25	36	Chair
725	Male	26-35	16	Constricted
766	Female	26-35	46	Constricted
801	Female	18-25	46	Chair
875	Female	36-45	16	Constricted
925	Male	18-25	46	Constricted
929	Male	26-35	46	Constricted
955	Female	26-35	36	Chair
979	Female	36-45	36	Chair
994	Male	18-25	46	Normal
1177	Male	36-45	46	Constricted
1303	Male	26-35	26	Enlarged
1369	Male	18-25	36	Constricted
1407	Male	≥46	26	Constricted
1495	Female	18-25	36	Chair
1550	Male	26-35	16	Chair
1635	Female	26-35	36	Chair
1664	Male	26-35	46	Constricted
1686	Female	26-35	16	Chair
1696	Female	≥46	46	Constricted
1855	Male	18-25	36	Constricted
1883	Male	≥46	36	Chair
1887	Male	≥46	26	Constricted

Table 1: Summary of individuals included in this study.

Constricted

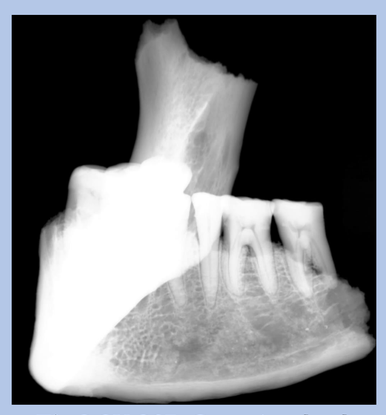


Fig.2 SK 367: Constricted pulp chamber of right first molar.

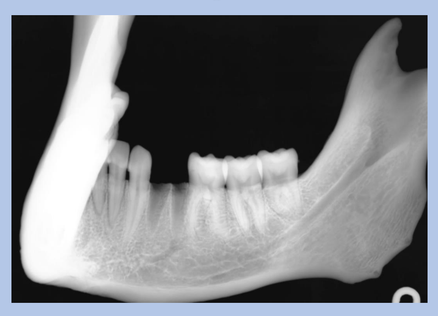


Fig.3 SK 925: Constricted pulp chamber of right first, second, and third molar.

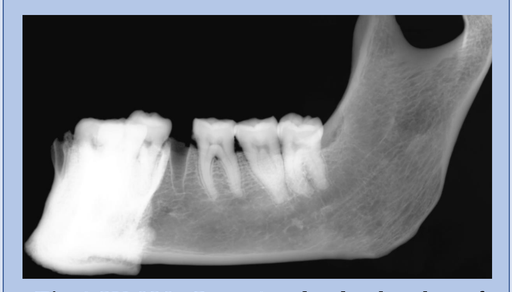


Fig.4 SK 929: Constricted pulp chamber of right first molar.

Enlarged

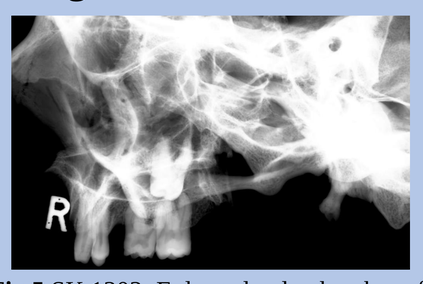


Fig.5 SK 1303: Enlarged pulp chamber of left first molar.

Chair Shape

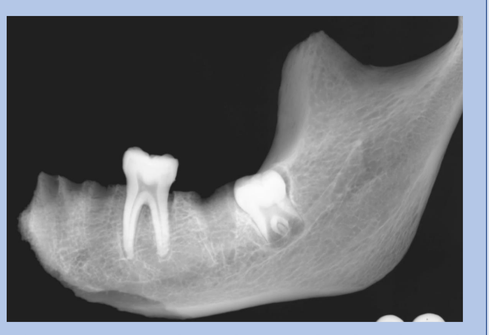


Fig.6 SK 801: Chair shape pulp chamber of right first molar.

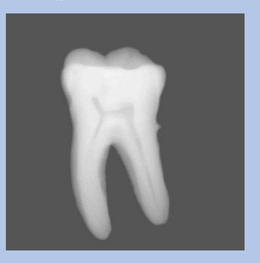


Fig.7 SK 979: Chair shape pulp chamber of lower left first molar.

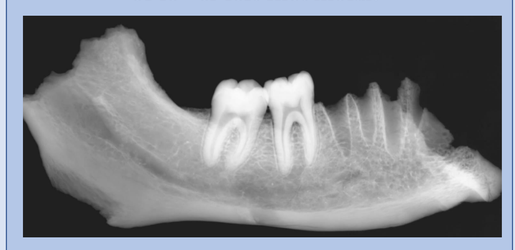


Fig.8 SK 723: Chair shape pulp chamber of left first molar.

Normal

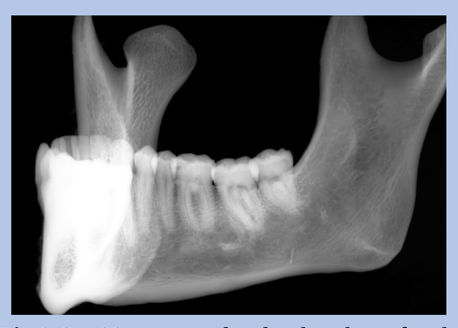
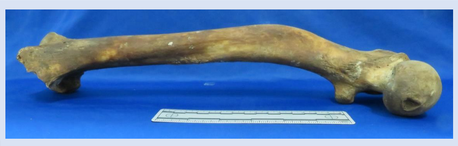


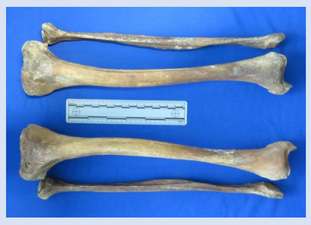
Fig.9 SK 994: Normal pulp chamber of right first molar.

Discussion and Conclusions

- Of the 30 individuals analysed, 28 exhibit morphological changes to the pulp chamber consistent with vitamin D deficiency. Deficiency must occur during pulp chamber formation for morphological changes to arise (1.5-2 years in males, and 1.4-2 years in females), therefore these results suggest that the vast majority of adults in this sample group experienced prolonged vitamin D deficiency ~1.5 years of age.
- Two individuals exhibit change in the first, second, and third molars, indicating chronic or recurring deficiency throughout childhood. Neither exhibited skeletal evidence for vitamin D deficiency.
- SK1303 exhibited an enlarged pulp chamber. Clinically, this has been linked to both vitamin D-resistant hypophosphatemic rickets and odontogenesis imperfecta.[6] This individual is currently the subject of further research, as they also exhibit skeletal change consistent with residual rickets (See Figs.10-13).

The results of this study indicate that childhood vitamin D deficiency was much more prevalent within this burial population than skeletal evidence has previously suggested. The timing of deficiency recorded in the first permanent molar is consistent with the age at which rickets is most common (6-24 months). The limited evidence for residual rickets in this population suggests that either the level of deficiency required to cause alteration to the pulp chamber is less than that required to cause skeletal change, or alternatively, that the re-modelling of bone throughout life has caused the loss of skeletal evidence for deficiency in all but two individuals.





Figs.10-13(L-R) SK 1303: M-L bowing of tibiae, cuspal enamel hypoplasia of upper left first molar, linear enamel hypoplasia of anterior dentition, A-L bowing of right femur.

Acknowledgements:
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