

## Abstract

Dental pathologies such as linear enamel hypoplasias (LEHs), periapical lesions (abscesses), dental calculus and caries, and ante-mortem tooth loss (AMTL) can indicate physiological stress during childhood development as well as reflect biocultural markers of nutrition and oral infection. Combined, they provide a powerful indicator of differential access to resources and dietary variation. This research explores the frequencies of these pathologies in two samples from the ancient Nabataean capital city of Petra to illuminate their relationship to social stratification. The mortuary repertoire of Petra includes ornate monumental façade tombs surrounding the city center in addition to less elaborate shaft chamber tombs. Previous archaeological research explains these tomb variants as reflecting family groups of higher and lower social status, respectively. Statistical analysis of dental pathology frequencies in 696 teeth from the non-elite tombs, 234 teeth from the elite façade tombs, and 132 teeth from a contemporary non-urban site identified statistically higher frequencies of dental calculus ( $\chi^2=29.750$ ,  $p<0.0001$ ), LEHs ( $\chi^2=54.855$ ,  $p<0.0001$ ) and AMTL ( $\chi^2=24.57$ ,  $p<0.001$ ) in the elite façade tombs, and no differences in dental caries or abscesses. The higher frequency of LEHs suggests that the elite individuals more often experienced stress during childhood development. However, in reality more observations of LEHs point to a higher frequency of childhood stress survival. Unfortunately the limited subadult remains from both contexts hinders understanding the relationship between LEH frequencies and childhood morbidity and mortality.

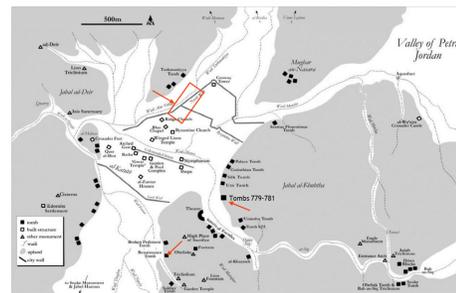


Figure 1: Location of Petra and map showing location of all tombs except for Hinterland Tomb 10

## Background and Research Hypotheses

- Petra was the capital city of the Nabataean Kingdom as well as a major trade center in the 1<sup>st</sup> century B.C.–A.D.
- Archaeological excavations have identified socio-economic stratification in terms of size and decoration of domestic areas and differences in tomb architectural elaboration (Figures 2 & 3) (Perry 2016; Schmid 2002; Wadeson 2012).
- Dental pathologies of individuals within elite and non-elite tombs are hypothesized to reflect this hierarchy:
  - Evidence of childhood stress (linear enamel hypoplasias) is expected in the non-elite tombs.
  - Dental caries, antemortem tooth loss, calculus, and abscesses will be higher in the elite tombs, reflecting a varied diet with more carbohydrates, particularly imports such as wheat.
- Individuals from one tomb in Petra's hinterland is included as an outgroup (Figure 4).

## Materials and Methods

- Recorded dental caries, dental calculus, antemortem tooth loss (AMTL), abscesses, and linear enamel hypoplasias (LEHs) following Buikstra and Ubelaker (1994).
- Ages that LEHs occurred calculated following Goodman and Rose (1990).
- Sample sizes reported in Table 1

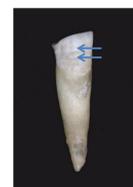
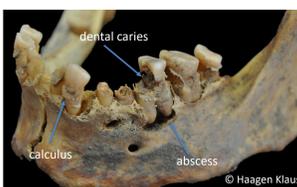


Table 1: Sample size of each tomb type

Tomb type	MNI	# teeth
Façade tombs	54	234
Shaft tombs	120	696
Hinterland tomb	8	132

Linear enamel hypoplasias (LEHs)

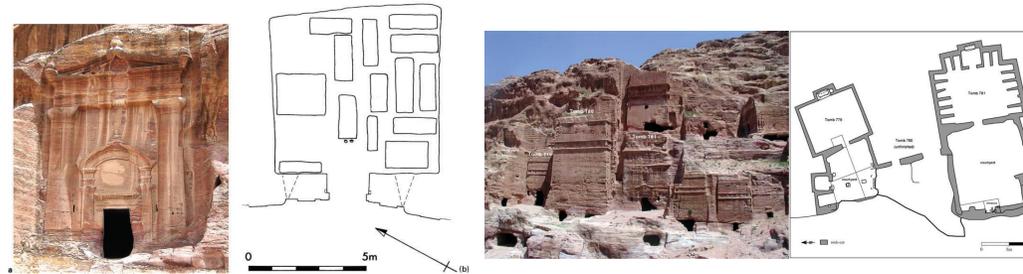


Figure 2: Monumental Tombs at Petra: the Renaissance tomb to the left (Wadeson 2010) and Tombs 779 and 781 at right (Wadeson 2012)



Figure 3: Petra North Ridge Tombs: shaft openings of Tombs B.7 and B.9 (left) and still image of 3D model of Tomb F.1 interior (right; courtesy of Thad Wasklewicz).



Figure 4: Petra Hinterland Tomb 10 before excavation (Wadeson and Abudana 2016)

## Results

- Façade tombs exhibited significantly higher rates of LEHs and dental calculus when compared to shaft chamber tombs (Figure 5).
- Both façade tombs and shaft chamber tombs exhibited significantly less antemortem tooth loss than the comparative Hinterland tomb (Figure 5).
- The estimated age of occurrence distributions for the LEHs remained consistent across all tomb types (Figure 6).

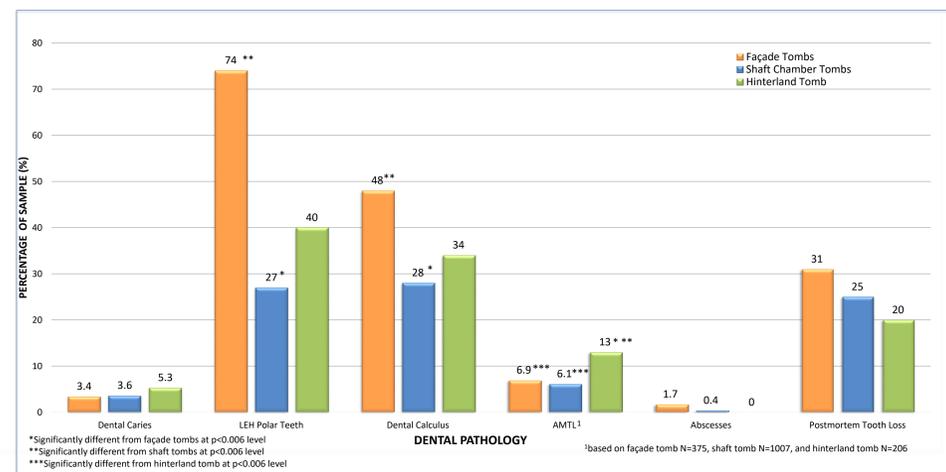


Figure 5: Frequencies of dental pathologies by tomb type at Petra

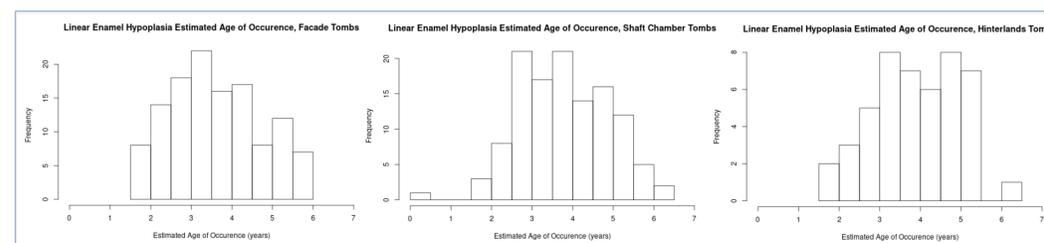


Figure 6: Distribution of LEH age occurrence by tomb type

## Discussion

- Similar frequencies of **dental caries** and **abscesses** suggests that the Nabataean diet did not vary across presumed social strata, or between urban and hinterland contexts.
- Poor preservation of the sample could have resulted in undercounts in caries and abscesses.
- AMTL of teeth with dental caries also could result in under-representation of this pathology (e.g., hinterland tomb has a significantly higher AMTL rate than the other tomb types, so they may have had a high caries rate as well but these teeth were lost).
- High **dental calculus** frequency in the façade tombs versus the shaft tombs may represent a higher carbohydrate or protein and/or low fluid intake by the elites or greater grit in the diet of the non-elites (Lieverse 1999).
- Poor preservation in the shaft tombs could also result in postmortem, taphonomic loss of calculus deposits
- The notably higher frequency of **LEHs** in polar teeth in the façade tomb than the shaft tomb individuals on the surface suggests they suffered from more nutritional and disease-related stress during childhood.
- LEHs however are only visible when an individual survives the stressful event, perhaps indicating the shaft tombs individuals had greater frailty during childhood.
- Very few remains of non-adult individuals were actually found in any tombs, creating difficulty for testing this assumption through other paleopathological indicators.
- Studies on living children have noted that LEH development often corresponds with the nutritional and immunological consequences of weaning (Goodman et al. 1987)
  - Thus the consistent increase in LEH development between 2 and 3 years of age across all tombs might indicate the start of the weaning period, when breastmilk is first supplemented with and then replaced by solid foods.

## Conclusions

Socioeconomic status as demonstrated by tomb architecture at Petra did not appear to profoundly affect dietary choice at Petra, a hypothesis that can be explored via isotopic analysis of diet. However, the elite individuals in the façade tombs more often suffered from and survived stress than those in the shaft tombs. The dramatic increase of LEH development between 2 and 3 years of age may indicate the period that weaning began, which did not differ between tomb types.

## Acknowledgements

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