



# Evaluating Enthesal Changes and Pathological Conditions in Bronze Age Arabia using the Patella

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## Background

This study examines patellae from individuals interred in tombs that date to the Umm an-Nar (ca. 2700-2000 BCE) in the United Arab Emirates, a period that featured an intensification of oasis agriculture, fortification architecture, bronze metallurgy, and interregional trade networks (Potts, 2012). Umm an-Nar people also engaged in burial practices that appear to be egalitarian as the tombs contained people of all ages and sexes, despite growing social hierarchies among the living (Gregoricka et al., 2021).

Umm an-Nar tombs Unar 1 (**Figure 1**) and Unar 2 (**Figure 2**) are found at the Shimal Necropolis in the Emirate of Ras al-Khaimah. Both tombs contain the cremated bones of hundreds of individuals that, over time, became commingled and fragmentary.



Figure 1: Tomb Unar 1 (2400-2200 BCE)



Figure 2: Tomb Unar 2 (2300-2100 BCE)

## Hypotheses

- If tomb membership is based on social divisions related to intensive activity patterns, there will be a higher prevalence of enthesal changes (EC) and osteoarthritis (OA), as evidenced in patellae, in either Unar 1 (U1) or Unar 2 (U2).
- The presence of vastus notches and EC will be associated with one another. Since vastus notches are either genetic or stress-related, kinship and/or demanding activity will cause a difference in vastus notch frequency between the tombs.
- There will not be bilateral asymmetry in the prevalence of EC or OA in the patellae because both sides are typically changed by strenuous activity (Refai, 2019), and OA often becomes bilateral with age (Metcalf et al., 2012).

## Material and Methods:

**Enthesal Changes.** We recorded how fragmentary each of the 711 patellae were from both tombs and, when too incomplete or too taphonomically damaged, coded them as not recordable (NR) or not scorable (NS), respectively. We scored the superior quadriceps femoris tendon enthesis (QFTE) and the inferior patellar ligament enthesis (PLE) separately. Each enthesis was observed for the presence of proliferative enthesophytes and osteolytic enthesopathy (Mariotti et al., 2004; **Figure 3**).

- Unar 1: 94 QFTE and 38 PLE were scorable for EC; 26 were scorable for both.
- Unar 2: 153 QFTE and 100 PLE were scorable for EC; 62 were scorable for both.

Each patella was also given an overall present or absent score for enthesal changes.

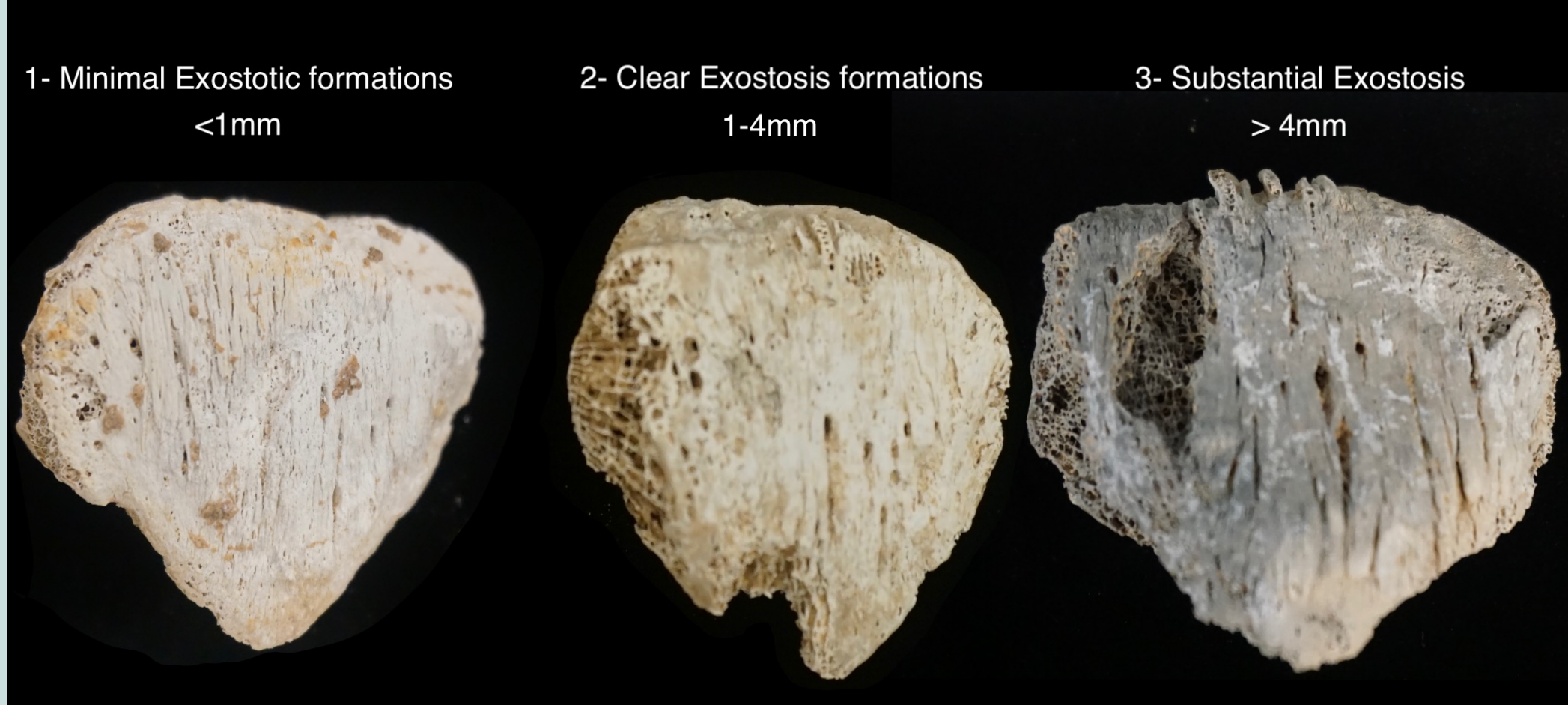


Figure 3 (above): U1 and U2 patellae illustrating Mariotti and colleagues' (2004) scoring system.

Table 1 (right): Buikstra and Ubelaker's (1994) scoring system for OA.

Buikstra and Ubelaker's (1994) Osteoarthritis Scoring System	
Criterion	Values
Lipping degree	1: barely discernible 2: sharp ridge or curved with spicules 3: extensive spicule formation 4: ankylosis
Lipping extent of circumference affected by most severe expression	1: <1/3 of circumference 2: 1/3-2/3 of circumference 3: >2/3 of circumference
Porosity degree	1: pinpoint 2: coalesced 3: both pinpoint and coalesced present
Porosity extent of surface affected	1: <1/3 of circumference 2: 1/3-2/3 of circumference 3: >2/3 of circumference
Eburnation degree	1: barely discernible 2: polish only 3: polish with groove(s)/impression(s)
Eburnation extent of surface affected	1: <1/3 of circumference 2: 1/3-2/3 of circumference 3: >2/3 of circumference

**Osteoarthritis.** The presence of OA was recorded using Buikstra and Ubelaker (1994; **Table 1**). Each trait was only scored if >25% of either the margin and/or the articular surface was present and relatively well-preserved. There were 211 patellae from Unar 1 and 334 from Unar 2 that were scorable for OA (**Figure 4**). These scores were then collated into an overall present or absent score for osteoarthritis.

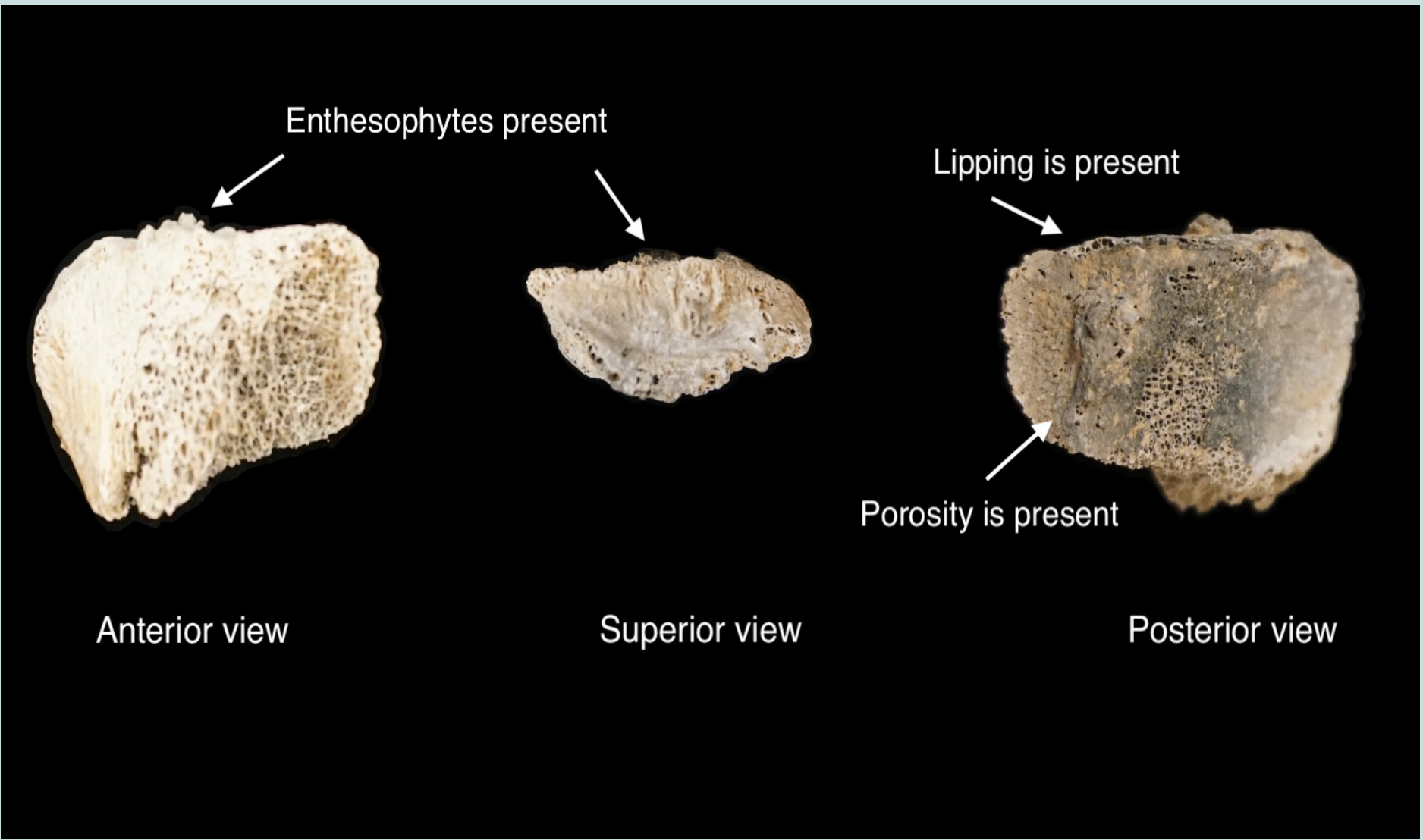


Figure 4: Individual U1.39.282 displaying proliferative enthesophytes, lipping, and pinpoint and coalesced porosity.



Figure 5: Vastus notch present in individual U1.39.253.

**Vastus Notch (VN).** The presence or absence of a vastus notch (**Figure 5**) was also evaluated in Unar 1 (n=154) and Unar 2 (n=254) if the superolateral portion of the bone was present, identifiable, and relatively undamaged.

## Results

Statistical analyses were performed on scoreable patellae using Chi-square tests ( $\chi^2$ ). Odds ratios (OR) were also used to determine the strength of association among different indicators. Results indicated:

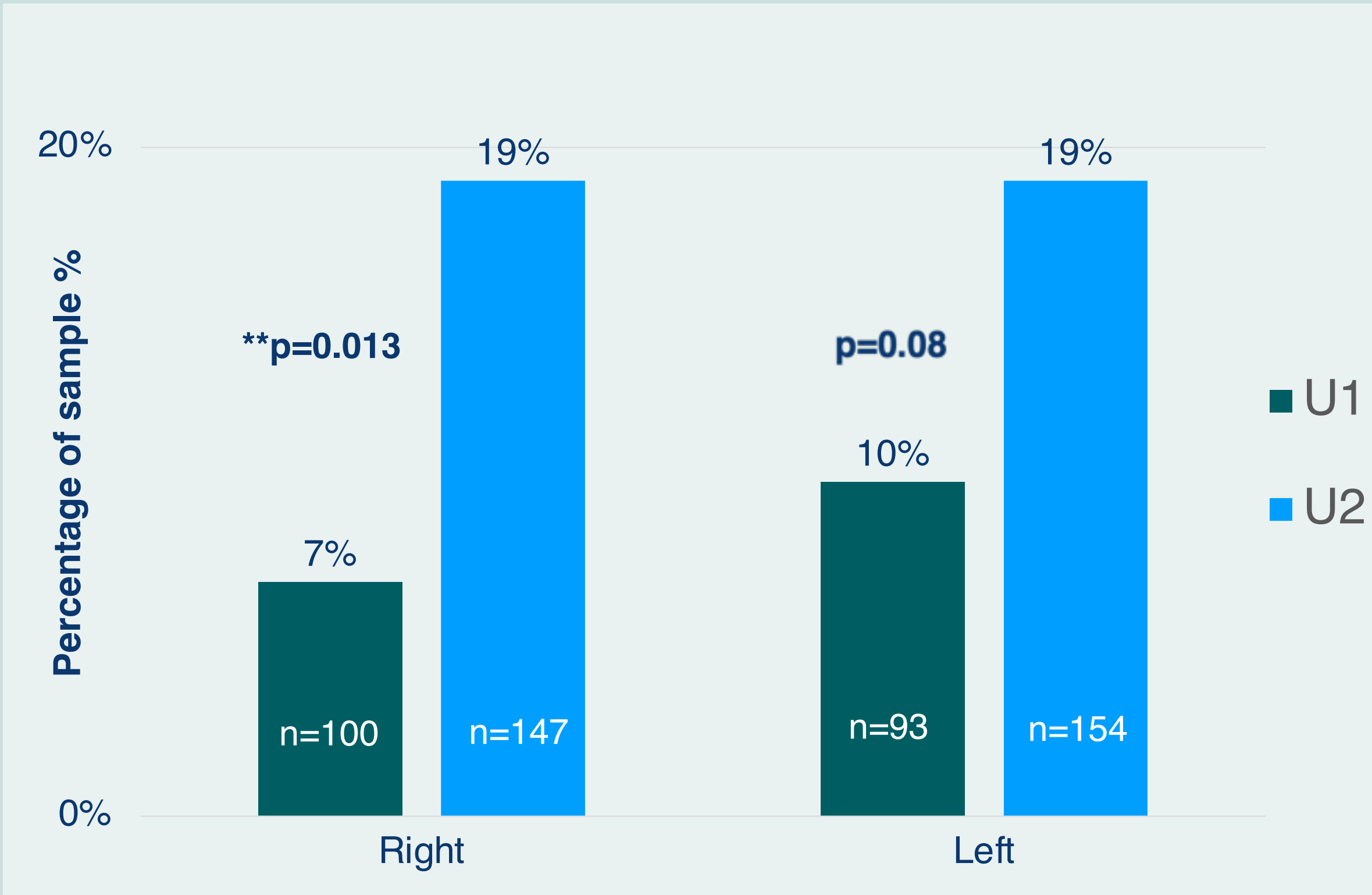


Figure 6: Osteoarthritis of the patella by side in tombs Unar 1 and Unar 2.

\*=p<0.05 \*\*= p<0.01

- OA b/w tombs:** A statistically significant difference in OA presence was found between U1 & U2 ( $\chi^2 = 8.63$ , df=1, p=0.003).
- OA by side b/w tombs:** When assessed by side, R patellae had a statistically significant difference in OA between tombs ( $\chi^2 = 6.15$ , df=1, p=0.013) in comparison to no difference on the L side ( $\chi^2 = 3.06$ , df=1, p=0.08) between tombs (**Figure 6**).

- OA by side, cont.:** U2 R patellae were more likely to have OA than U1 R patellae (OR=3.13, 95% CI [1.31-7.47]). When porosity is excluded as diagnostic criteria (McClain, 2013), the U2 L patellae were also more likely to have OA than U1 L patellae (OR = 2.9, 95% CI [1.07-8.04]).

- EC & VN b/w tombs:** No statistically significant difference in EC ( $\chi^2 = 0.48$ , df=1, p=0.48) or vastus notch presence ( $\chi^2 = 0.4$ , df=1, p=0.53) was found between U1 & U2.

- EC, VN, & OA:** In U1, R patellae with EC were more likely to have OA (OR = 5.03, 95% CI [1.88-13.45]). In both tombs, patellae with EC were more likely to have VN (**Table 2**).

- Within each tomb, no significant differences between sides (p>0.05) for any conditions were found, suggesting that activities were performed using both knees.

Table 2: Odds ratios describing the odds of having OA (including porosity) by side when EC are present and the odds of having a vastus notch when EC are present

	EC Unar 1	EC Unar 2
OA Left	2.39	1.1
OA Right	5.03**	1.07
Vastus L	2.7*	2.4**
Vastus R	1.3*	2.8**
*=p<0.05 **= p<0.01		

## Discussion & Conclusions

The higher frequency of OA in Unar 2 may suggest that people were engaging in more repetitive and weight-bearing activities, likely due to agricultural demands. It is also possible that they lived to older ages, as OA tends to increase with age.

Since both EC and OA can be the result of repetitive and stressful movements of the knee, it is unsurprising that they co-occur at a high rate in Unar 1 (**Table 2**). It is notable that this is not the case in Unar 2, suggesting that the presence of OA in Unar 2 may be related more to age than to activity. The association between vastus notch presence and EC in both tombs (for both sides of the patella) may mean one of two things:

- If vastus notch presence is related to stress, its association with EC is logical.
- If vastus notch presence is genetic, there may be kin groups within the tombs that experienced similar weight-bearing activities.

These results are different from those of the nearby Umm an-Nar site of Tell Abraq. The patellae at Tell Abraq had much higher rates of QFTE EC, attributed to their participation in activities similar to modern fisherman (Osterholtz et al., 2019), when compared to Unar 2 ( $\chi^2=190.93$  df=1, p<0.0001) and Unar 1 ( $\chi^2=131.66$  df=1, p<0.0001). This may suggest that the individuals interred at Shimal were not participating in fishing activities. The frequency of vastus notch presence at Tell Abraq is statistically similar to our sample from both Unar 1 (p=0.84) & Unar 2 (p=0.33). The prevalence of the vastus notch varies between biologically-isolated populations (Taylor, 2021), potentially suggesting gene flow between these groups.

Further research should explore the effects of sex on pathological conditions using the patella as well as the prevalence of OA and pathological conditions in the femora.

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