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Characterising the Frictional Properties of Haemarthritic Articular Cartilage

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1. Introduction

- Recurrent bleeding is a major clinical manifestation of haemophilia with the average patient experiencing at least one bleed per year (1).
- Known as haemarthrosis; bleeding into the joint space over time can cause disabling, polyarticular haemophilic arthropathy (2).
- Synovial joints can withstand harsh loading regimes as articular cartilage supports and redistributes joint contact forces by providing a smooth, low friction gliding surface. This is aided by synovial fluid providing effective lubrication (3).

There is limited research on the type of mechanical stress that occurs during haemarthrosis. Using lubricant conditions representative of a synovial joint at different stages of haemorrhage, the changes in frictional properties of articular cartilage during haemarthrosis can be determined.

2. Methodology

A pin-on-plate configuration was used to determine the coefficient of friction (*COF*) of 'healthy' and 'haemarthritic' articular cartilage. Osteochondral pins (8 mm) from porcine tali underwent two-hour exposure periods prior to testing. Porcine pins were then articulated against a larger bovine femoral cartilage plate for 3600 seconds under a load of 50N. Different exposure fluids and lubricants were used to mimic a joint bleed *in vitro* (Fig. 1).

Stage of Joint Bleed	(Control)	Pre-Joint Bleed	Initiation of Joint Bleed	Transition	Peak of Joint Bleed	Recovery
Exposure Fluid		Serum	Serum	50% v/v	Blood	Blood
Lubricant Fluid	Serum	Serum	Blood	50% v/v	Blood	Serum

Fig. 1 | The progression of a joint bleed and the conditions used to replicate this *in vitro*. Test conditions consist of different exposure fluids and lubricants to mimic a joint bleed.

3. Results

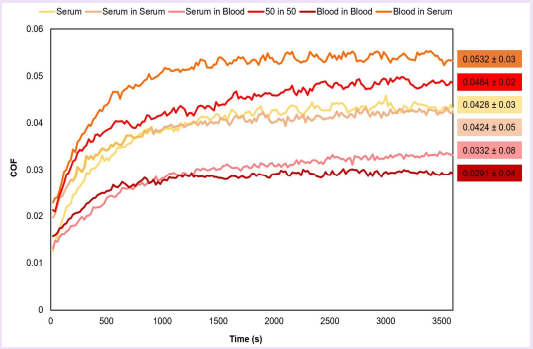


Fig. 2 | Coefficient of friction (COF) values produced by articulating 8mm porcine osteochondral pins against bovine cartilage plates in the pin-on-plate friction rig over a period of 3600 seconds. Articular cartilage tested in different exposure fluids and lubricants to mimic a joint bleed. COF expressed as mean ± SD (n=3).

- The highest COFs were produced by 50% v/v and blood in serum conditions (0.0532 ± 0.03, 0.0484 ± 0.02) (Fig. 2).
- The lowest mean COF was produced by the blood in blood condition (0.0291 ± 0.04) (Fig. 2).
- Statistical analysis reported no significant difference across the six conditions (ANOVA, p>0.05).
- Macroscopic observation found creep deformation in the serum in blood, 50% v/v, blood in blood and blood in serum conditions (Fig 3).
- After 24 hours, the wear scar produced under the haemarthritic conditions, 50% v/v and blood in blood, did not fully recover (Fig. 3).

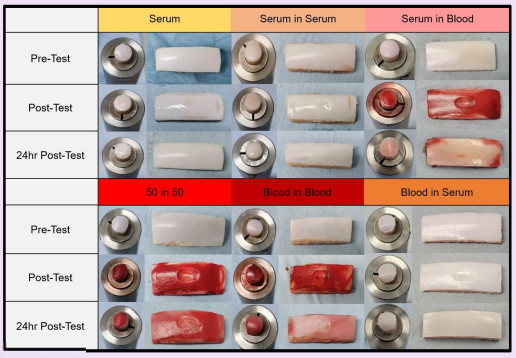
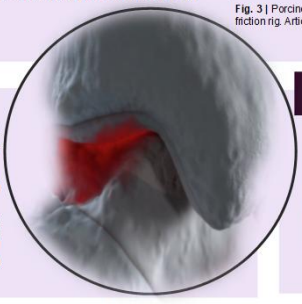


Fig. 3 | Porcine osteochondral pins and bovine plates pre-, post- and 24hr post-testing in the pin on plate friction rig. Articular cartilage tested in different exposure fluids and lubricants to mimic a joint bleed.

4. Discussion

- A time-dependent response was illustrated across all six test conditions before reaching equilibrium. This is in agreement with previous studies conducted on healthy articular cartilage reflecting its biphasic nature (4, 5, 6).
- Whole blood has similar lubricant properties and protein composition to synovial fluid which could explain the lower COF (7).
- When blood is introduced into the joint space, it mixes with variable amounts of synovial fluid. Haemarthritic synovial fluid is less viscous than healthy synovial fluid (8). The 50% v/v offers higher clinical significance in this respect. Dilution of whole blood with serum alters its lubricant properties explaining the differences in COF (9).



5. Conclusion

Articulation of articular cartilage in the presence of whole blood and mixed lubricants resulted in changes to the coefficient of friction as well as damage to the articular surface. This demonstrates the burden of haemophilia as one joint bleed has the potential to damage articular cartilage.

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