Comparison Between *In Vitro* and Simulated Arthroscopy Electromechanical Measurements of Human Articular Surfaces Using the Arthro-BST

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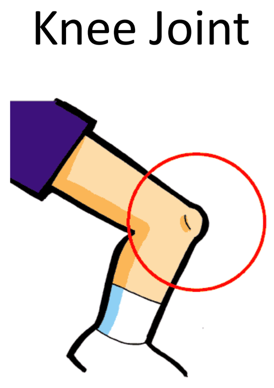
Introduction

Compression-induced streaming potentials of articular cartilage can be measured through the electromechanical probe Arthro-BST (Biomomentum Inc., Laval, Canada). Initially, the output value of this probe was calculated based on streaming potentials integrals (SPI) at a predefined area of contact between its spherical indenter and the cartilage.[1; 2] Here we examine an improved output called the quantitative parameter (QP), proportional to the area of contact for a predefined SPI[3; 4]. This new QP analysis presents significant advantages over former calculation including robustness to noise.

This study investigates whether the Arthro-BST QP improves the reliability of cartilage assessment in simulated arthroscopy.

Materials and Methods

Fresh Cadaveric Knee Joint

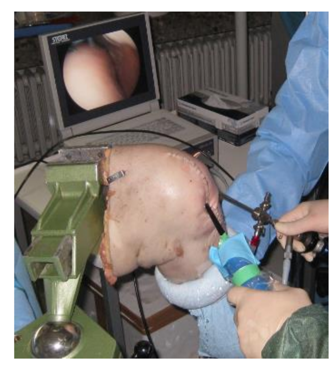


Science Care (Arizona, USA)

Surgically opened to define 12 measurement sites on the distal **femur with a permanent marker**

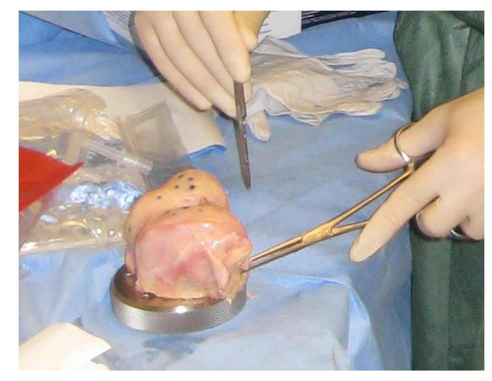
Closed the wound with sutures

Held in 90° of flexion to perform **electromechanical assessment** by a surgeon



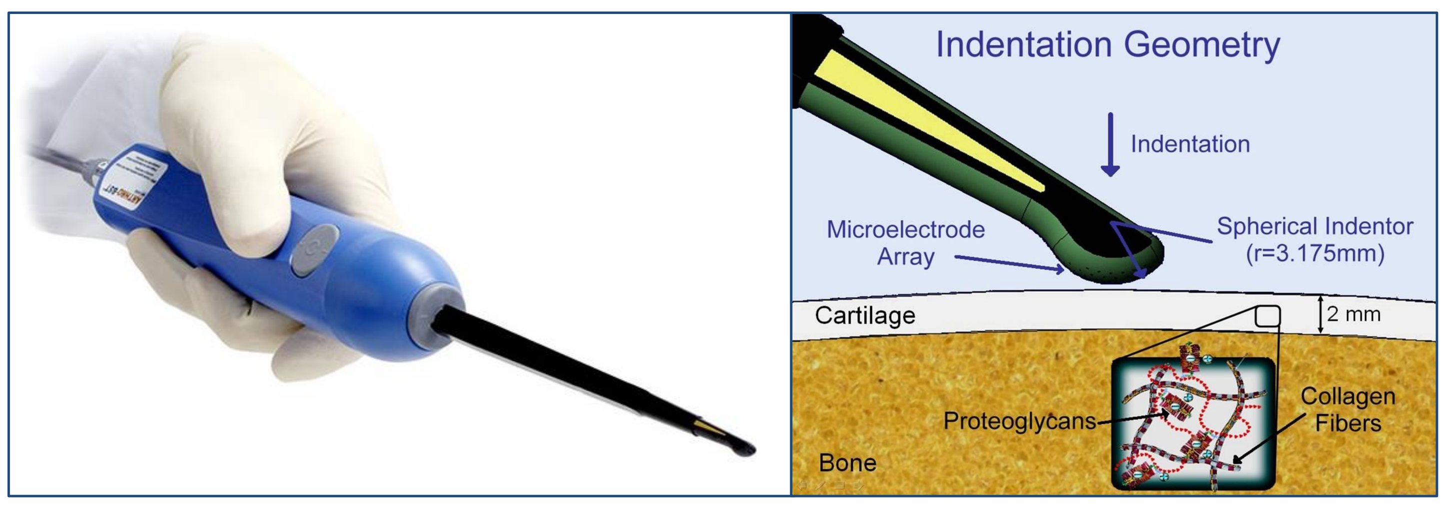
Simulated Arthroscopy

Distal femur was isolated to perform *ex vivo* **electromechanical assessment** by 4 users (**the orthopaedic surgeon and 3 engineers**)



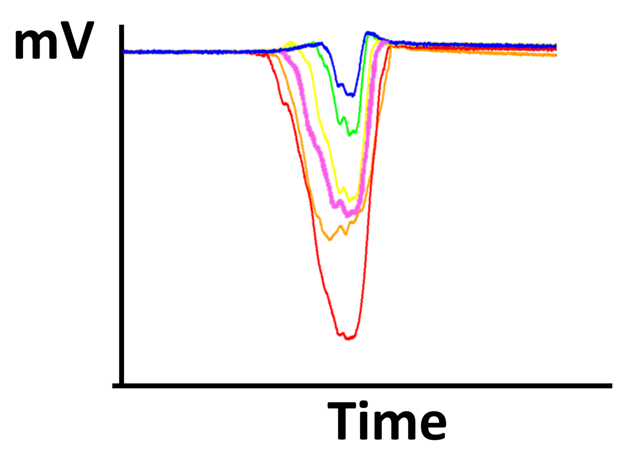
Ex vivo

Biopsies are extracted for **macroscopic visual ICRS scoring[5]** and **histological Mankin scoring[6]**



The Arthro-BST is an arthroscopic device that directly measures cartilage **streaming potentials** by compressing cartilage with a spherical indenter containing an array of 37 gold microelectrodes (r=3.2 mm, 5 microelectrodes/mm²).

measured streaming potentials



Former algorithm → SPI

Current algorithm → QP

Results

Intraclass Correlation Analysis (95%C.I.)

Between	SPI	QP
4 users	0.87 (0.71-0.96)	0.85 (0.68-0.95)
simulated arthroscopy and *ex vivo* measurements	0.64 (0.14-0.88)	0.89 (0.63-0.97)

Pearson's r correlation (*p*-value)

	SPI	QP
simulated arthroscopy and *ex vivo* measurements	0.63 (p=0.02)	0.83 (p=0.0009)
simulated arthroscopy and histological Mankin Score	−0.54 (p=0.07)	0.84 (p=0.0007)
simulated arthroscopy and visual ICRS score	−0.60 (p=0.074)	0.80 (p=0.001)

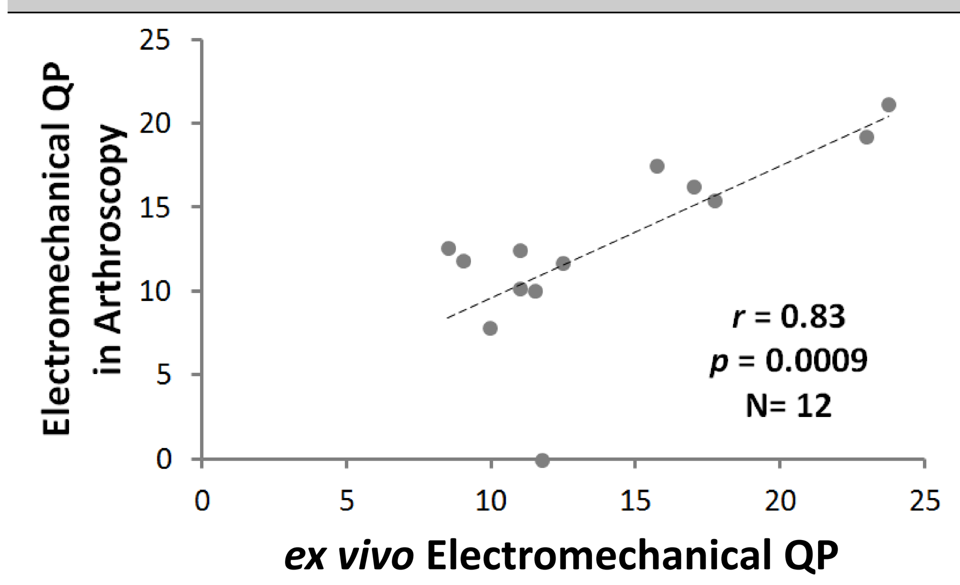


Figure 1. Positive correlation between simulated arthroscopy and *ex vivo* electromechanical QP values at 12 positions.

A high QP reveals cartilage degeneration, thus weaker electromechanical properties due to GAG depletion, swelling or loss of cartilage thickness and weakening of the collagen network. These changes in the cartilage also lead to higher histological Mankin scores and macroscopic visual scoring.

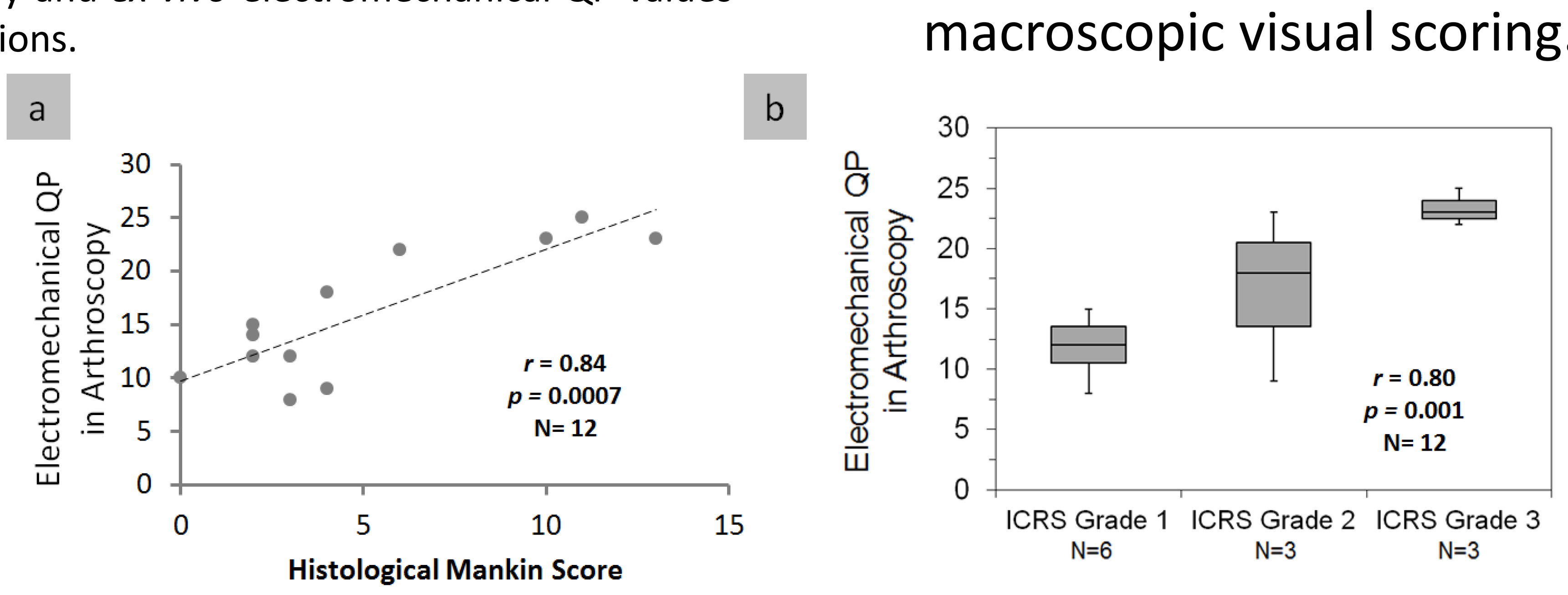


Figure 2. a) Positive correlation between electromechanical QP in simulated arthroscopy and histological Mankin Score. B) Positive correlation between electromechanical QP in simulated arthroscopy and ICRS Grade. Boxplots displays median values (central horizontal line), first and third quartiles (box) and 1.5 x interquartile range (bars).

Conclusion

- This study confirmed that the new QP analysis is still user-independent (a high ICC is maintained between users) and more robust to the noise induced by arthroscopy (fluid flow, debris on electrodes, contact with synovial membrane, etc.) demonstrated by a steep increase in the ICC and Pearson's *r* correlation compared to the former SPI calculation.
- The current QP is inversely proportional to the former SPI (a high QP is associated with degeneration), but is now directly proportional to gold standards such as histological or macroscopic scores.

❖ **These results (improved correlations with gold standards and high ICCs) support the use of the Arthro-BST output parameter. This will contribute to make the Arthro-BST a more powerful and robust tool for articular cartilage assessment under arthroscopy.**

Acknowledgments

Funding was provided by the National Sciences and Engineering Research Council (NSERC) and Biomomentum Inc.

References

[1] Abedian 2013, J Biomech 46:1328 [2] Becher 2015, Cartilage 7:62 [3] Sim 2014, Osteoarthritis Cartilage 22:1926 [4] Sim 2016, J Orthop Res DOI 10.1002/jor.23330 [5] Mainil-Varlet 2003, J Bone Joint Surg Am 85:45 [6] Mankin 1971, J Bone Joint Surg Am 53:523