Accuracy of the Iscan Pressure Measurement System

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Summary

The Iscan system can be used to measure continuously changing force and pressure distribution at biomechanical interfaces. The objective of this study was to determine how accurately the Iscan system measures force and force distribution in static loading. Known absolute and relative loads were applied to Iscan sensors using custom-built indentors loaded in a servohydraulic test machine. Over the 35 trials, the mean error for the absolute measurement of force was 6.5% and the standard deviation of the error was 4.4%. The mean error in the force distribution measurement over the 25 trials was 0.86 % and the standard deviation of the error was 0.58%. The results suggest that, when calibration, conditioning and testing protocols are developed carefully, the Iscan system measures force and pressure distribution more accurately than Fuji Prescale film.

Introduction

The transmission of load across biomechanical interfaces has been studied by making measurements in cadaver specimens and mannequins loaded to simulate *in vivo* mechanics. Fuji Prescale film (Fuji, Tokyo, Japan) has been used extensively to measure contact area and pressure, from which resultant load can be determined. This transducer is limited because only the peak pressure and total area are recorded for a given load cycle.

The Iscan system (Tekscan, Boston, MA) makes dynamic measurements of pressure, force and area. The system consists of a 0.1 mm thick, flexible printed circuit sensor, an interface to a personal computer and data analysis and acquisition software. Although some performance features of the system have been assessed under certain conditions [1,2,3], the system's accuracy has not been characterized completely.

The objective of this study was to determine how accurately the Iscan system measures force and force distribution in static loading.

Methods

In all tests, the Iscan sensor was loaded in a servohydraulic testing machine (Instron 1331, Canton, MA) between sheets of 1/8" thick rubber backed on the bottom with a machined aluminum base and on the top with one of several machined aluminum indentors. Both sides of the Tekscan sensor were lubricated with water and surgical jelly to reduce shear. In all tests, a 5 s long ramp function increased the load to the desired value, where it was then held for 5 s, at which point the force measurement was recorded. Applied force was measured with a calibrated load cell (Sensotec).

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Each Iscan sensor was conditioned and calibrated using a flat aluminum indentor that covered the sensor completely. The sensor was conditioned by loading it to 2.1 kN (120% of the maximum expected applied force) five times. The system was calibrated, using its preprogrammed two-point calibration routine, at 0.35 and 1.4 kN (loads corresponding to 20% and 80% of the maximum expected load).

Force accuracy was assessed by applying loads at 7 levels corresponding to mean pressures of 1-7 MPa through a flat-ended cylindrical indentor (266 mm^2). Five trials were performed at each load level. Accuracy was quantified by the mean absolute difference between the Iscan measurement of force and force measured with a calibrated load cell.

Force distribution accuracy was assessed by applying a resultant load of 1000 N through two flat-ended cylindrical indentors (123 mm^2) using a linkage to distribute the resultant force between the two at 5 known ratios. Five trials were performed at each load ratio. Accuracy in the relative distribution of force was defined as the difference between the applied higher force (calculated from the load cell measurement and the geometry of the linkage) and the Iscan measurement of higher force.

Results

Over the 35 trials, the mean error for the absolute measurement of force was 6.5% and the standard deviation of the error was 4.4 %. No relationship between applied force and measurement accuracy was evident (Figure 1).

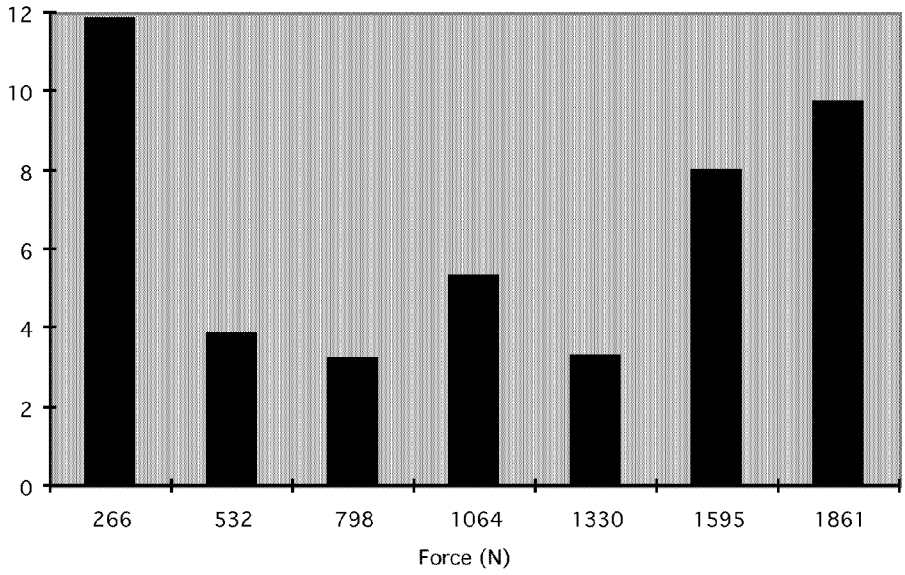

Figure 1. Error in force measurement (average of 5 trials)

The mean error in the force distribution measurement over the 25 trials was 0.86% and the standard deviation of the error was 0.58%. No relationship between applied force and measurement accuracy was evident (Figure 2).

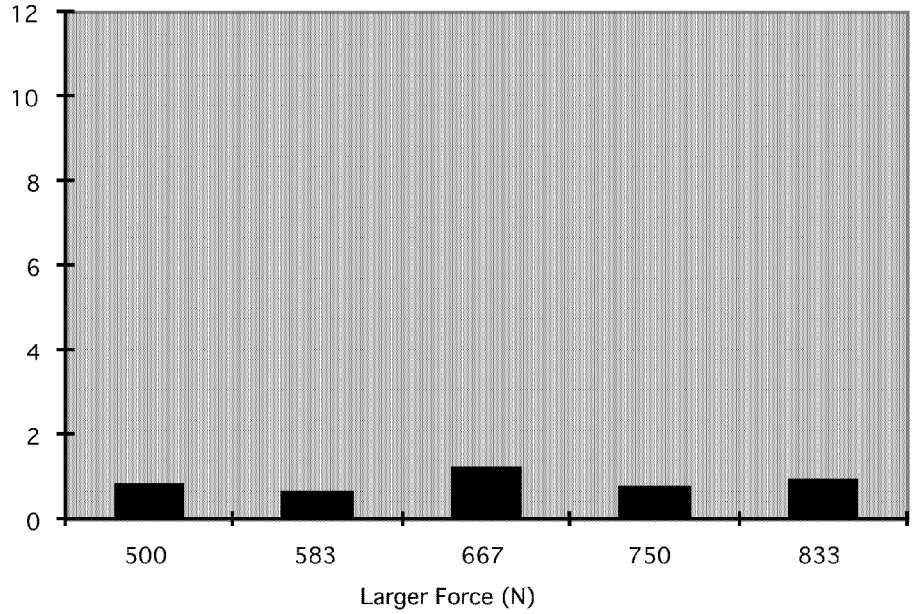

Figure 2. Error in force distribution measurement (average of 5 trials)

Discussion

Based on these results for the accuracy of force measurements and earlier calculations of the accuracy of Iscan area measurements (3%) [2], we conclude that the accuracy of the Iscan system's prediction of mean pressure is better than Fuji Film's (commonly acknowledged to be 10%).

The high accuracy of relative force distribution measurements makes the Iscan system useful in many biomechanical applications. The system can be used to study small changes in contact pressure and force distribution that could not be discerned by Fuji Film. In many applications it is more important to measure the change in contact pressure or force distribution than the absolute contact pressure or force.

It is important to note that the tests performed have been designed to minimize the effects of drift and hysteresis that the Iscan system displays [3], and that the accuracy with which the system measures a changing dynamic load may be substantially poorer than the static accuracy measured. One limitation of our study is that, although the compliance of a human diarthrodial joint has been approximated in these tests, the system may display different characteristics when measuring within the asymmetrical geometry and changing compliance of human joints and synthetic-human interfaces.

The Iscan system offers several advantages over Fuji Film: dynamic measurements can be made, the sensor is thinner and therefore interferes less with normal contact mechanics, and data acquisition and analysis is straightforward. Because Iscan's performance is comparable to Fuji Film's, it should be considered a valid means for measuring contact forces and force distributions at biomechanical interfaces.

Acknowledgements

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References

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