Investigation into the Mechanical Properties of Silicone Finger Implants

How does the body affect silicone finger implants and what can be done about this?

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Introduction

Currently in the UK, approximately 600,000 people suffer from Rheumatoid Arthritis [RA], with this number rising every year (Trail, et al., 2004). The immune system of people who suffer from RA attack the bodily tissues surrounding a joint; causing joint pain, swelling and stiffness which leads to impaired use and eventually destroys the joint (NHS, 2014). In 70% of cases the joints of the hand are affected (Watts, et al., 2015). If, due to their condition, the joints of the finger require replacement, in general a silicone finger joint replacement will be implemented; most commonly a Swanson implant,fig.1 .

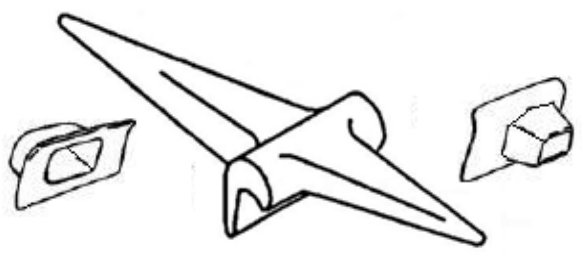


Figure 1, Swanson design (Pylios, 2010)

However these implants do not last as long as the current models of hip or knee replacements and have been found to degrade in the body, specifically many implants fracture fig.2 (Cowell, 2016). The aim of this research is to suggest how this degradation occurs, what properties it affects and find any possible solutions.

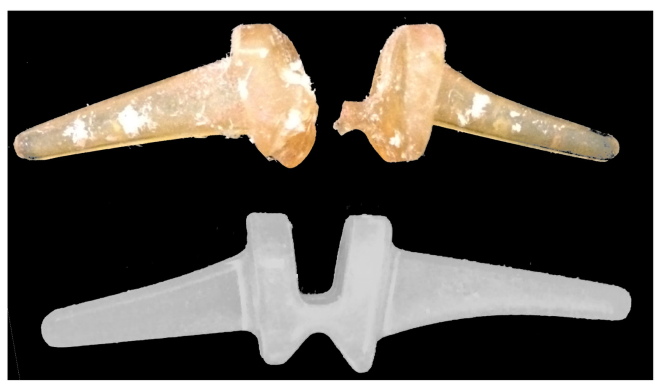


Figure 2, Degraded and New NeuFlex Silicone Finger Joint (Cowell, 2016)

Surface Scanning

Determining how much wear occurs inside the body is an important step in understanding the degradation of a prosthesis. The traditional method of weighing the prosthetic before and after is not suitable to measure those implants that have failed as the weight before is not known and cannot be guessed from products of the same design due to the extremely small weights involved (1000th of a gram).

The newly suggested method is to use a surface scanner. This machine takes images of the implant at varying depths. Combining only the sharp, in focus images gives the coordinates of the surface and cant be used to measure how the implant has varied from that of an unused implant fig.3.

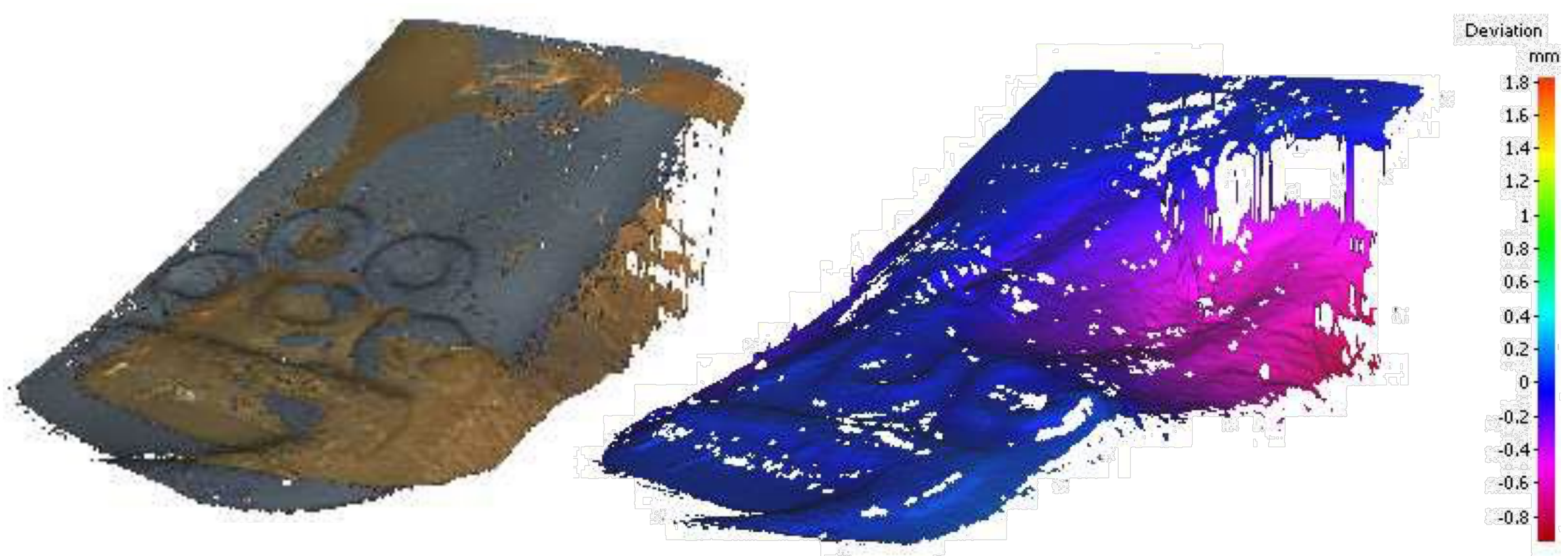


Figure 3, Silicone Implant Overlay and Difference Calculation

To justify the use of surface scanning it was required to be compare this to the current method. This was done by using steel bars, weighing them and scanning the surface then removing some material and reweighing and rescanning. The results showing the correlation between the two techniques can be found in fig.4

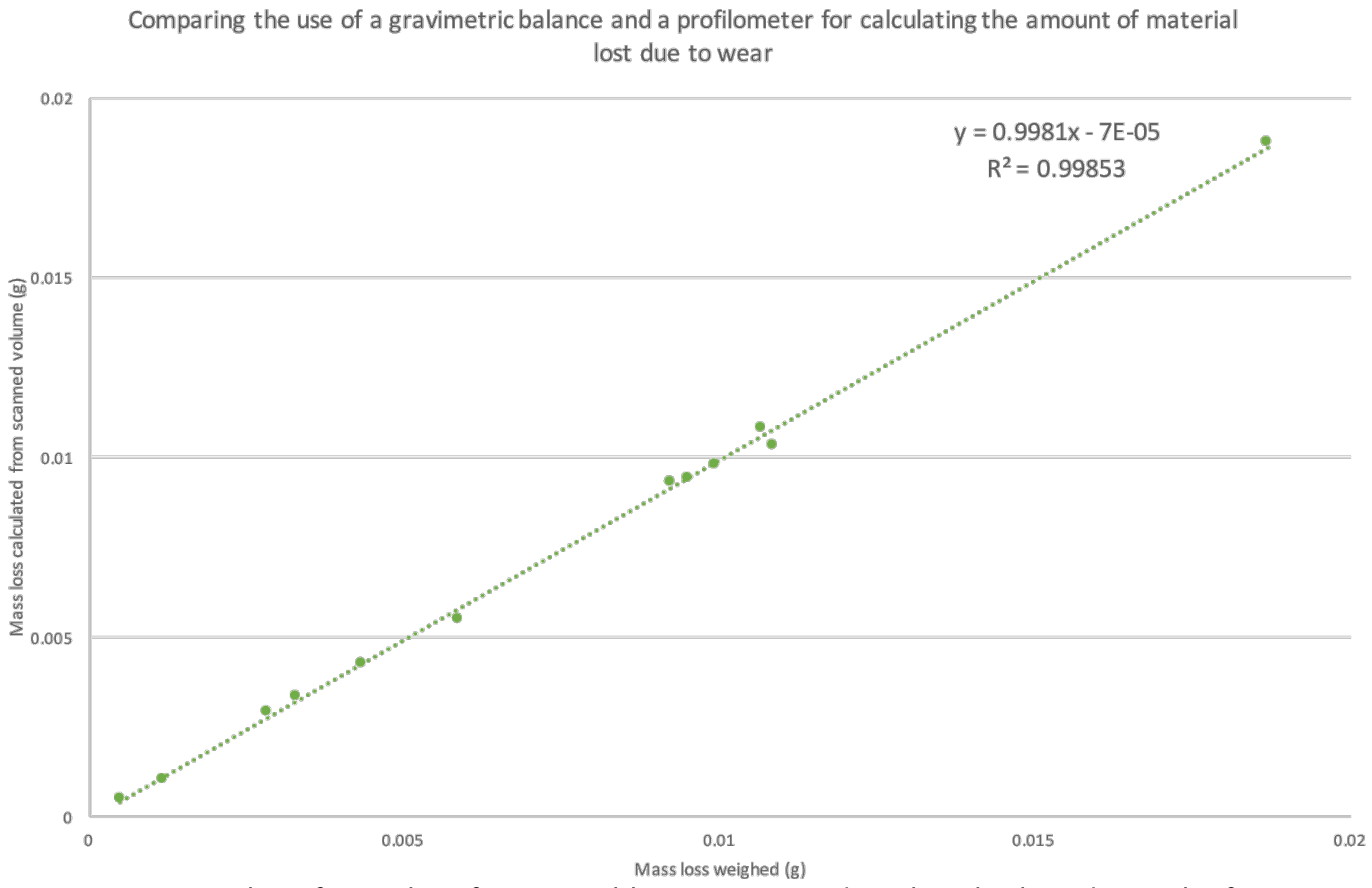
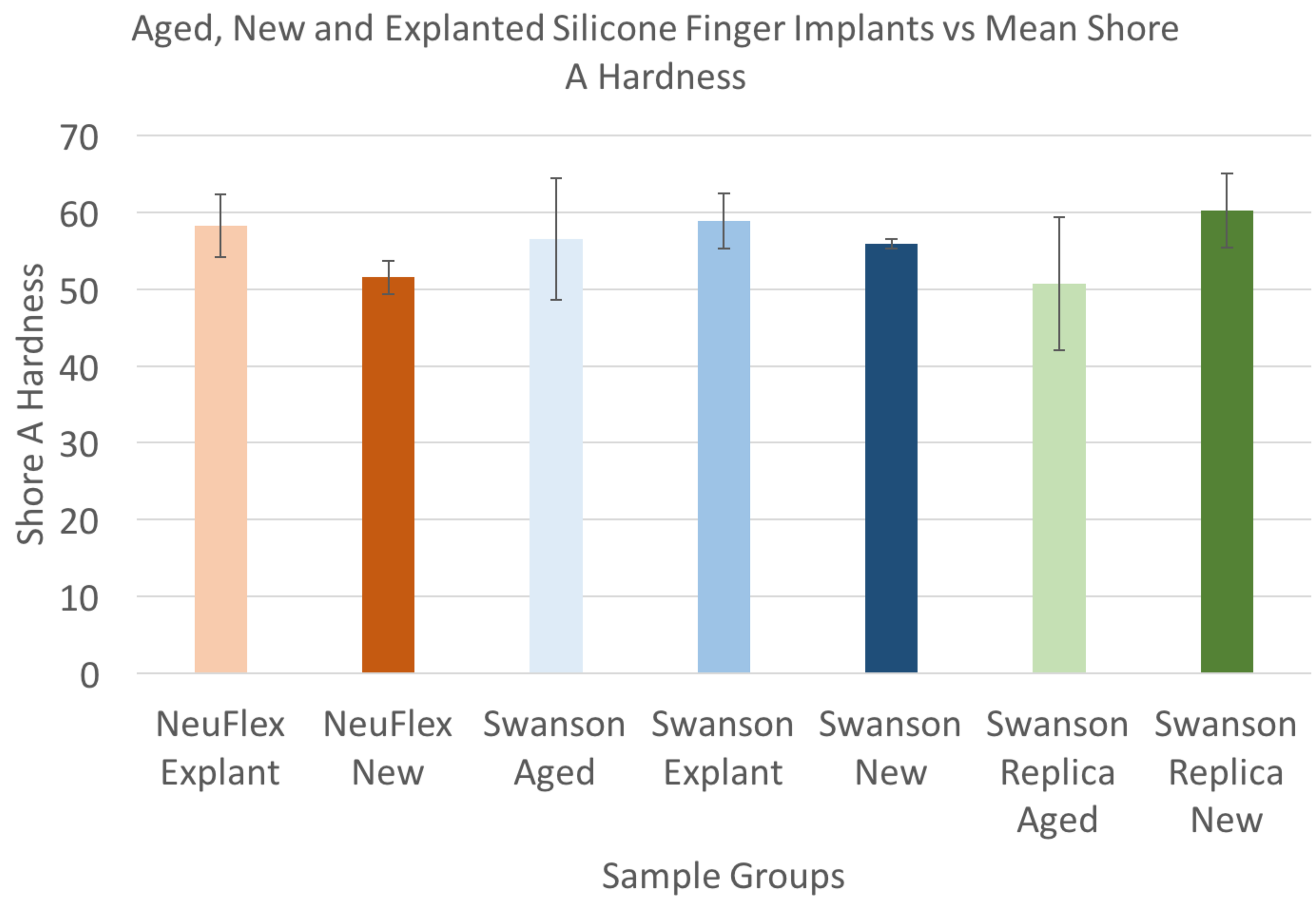


Figure 4, Results of weight of material lost compared with calculated weight from scan

Hardness and Cross-Linking

It has been suggested that an increase in hardness causes an increase in the rate that cracks grow in a silicone implant. A hardness test was completed on various makes of silicone implant. This involves using a durometer, a piece of equipment that drops an indenter onto the sample and measures the 'bounce-back' from the sample. The results shown in fig.6 indicate that the hardness of an implant increases while in the body.



Cross-linking has been identified as a possible cause of hardness increase. This chemical change adds bridges between the polymer chains of the silicone fig.7.

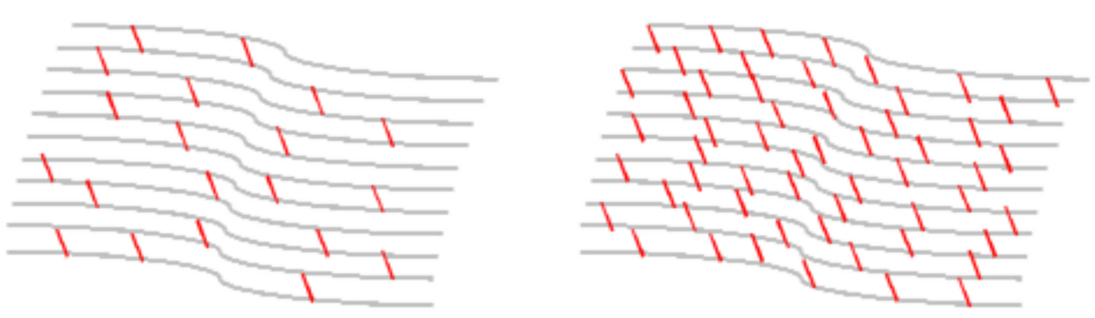


Figure 6, Increase in cross-link density

To test whether cross-linking occurs in the body the thermal properties of an unused implant and a used implant can be measured and compared. Differential scanning caliometry heated the samples from 50℃ to 580℃, measuring simultaneously the amount of energy used to heat up the sample and the current temperature of the samples. As shown in fig. 7 there is a large trough in both samples between 400℃ and 500℃. This indicates that a lot of energy is absorbed in the sample at that point. As this feature occurs at a later temperature in the pre-implantation samples it implies that this sample is more resistant to heat. Contradicting with the suggested increase in hardness from pre and post implantation this denotes an actual decrease in cross-link density. It is clear more chemical analysis is required to provide evidence for which of the two experiments is accurate.

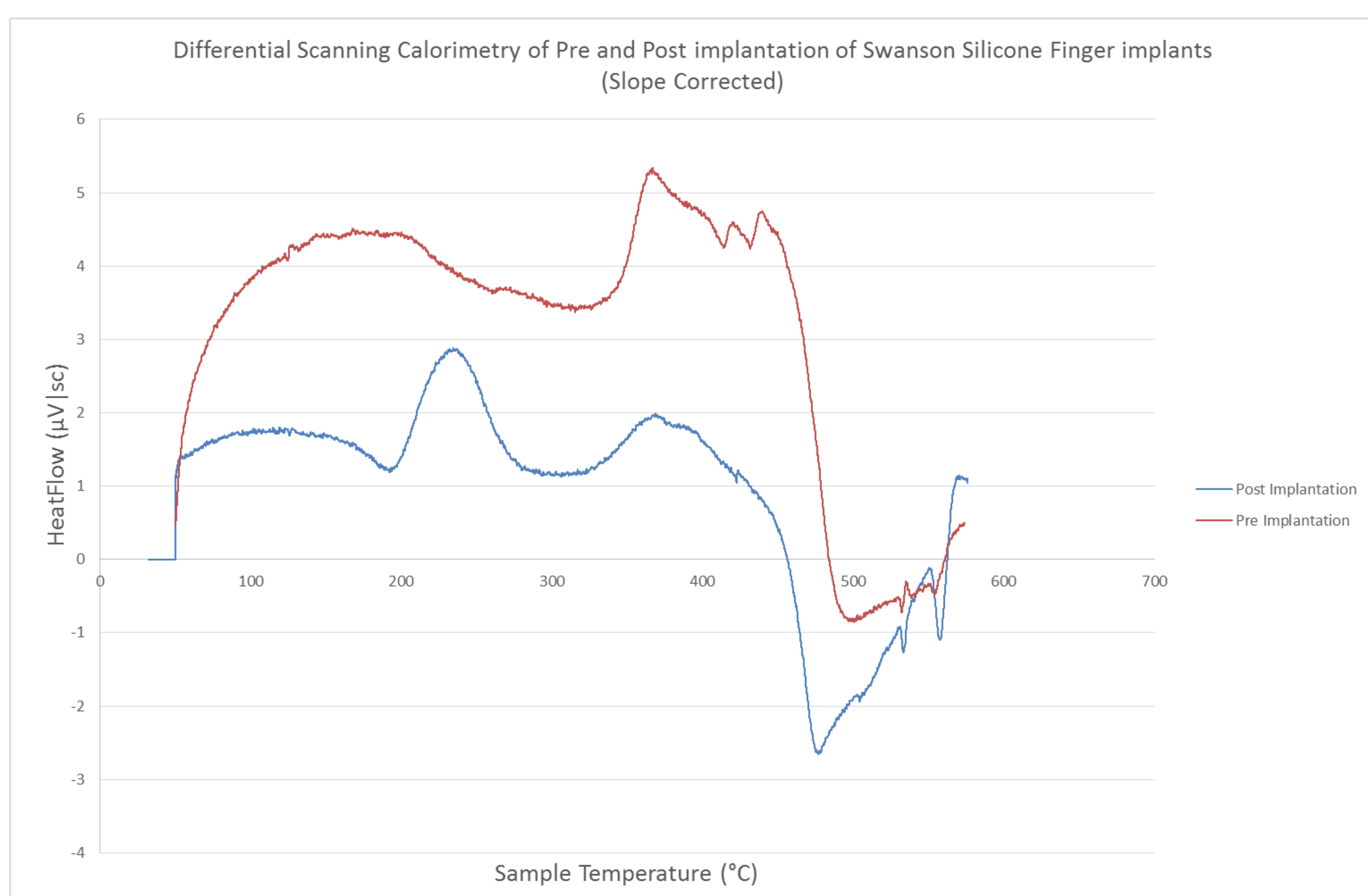


Figure 7, DSC of pre and post implantation of Swanson silicone finger implants (Slope Corrected)

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