Heberden Society

Clinical Meeting, March, 1973

At a clinical meeting held at Leeds on March 16, 1973, the Heberden Round was conducted by Prof. V. Wright and the following papers were presented.

Some New Evidence on Human Joint Lubrication. By A. UNSWORTH, D. DOWSON, and V. WRIGHT (*Leeds*)

The lubrication of human joints presents researchers with a great many problems. Various modes of operation have been suggested and evidence has been forthcoming in support of the following proposals:

- (1) Hydrodynamic lubrication (MacConaill, 1932).
- (2) Boundary lubrication (Charnley, 1959, 1960a,b; Little, Freeman, and Swanson, 1969).
- (3) Weeping lubrication (McCutchen, 1959).
- (4) Elastohydrodynamic lubrication (Tanner, 1966; Dowson, 1967).
- (5) Squeeze film lubrication (Fein, 1967).
- (6) Boosted lubrication (Walker, Dowson, Longfield, and Wright, 1968).

The present work shows that a greater understanding of the lubrication regimes can be obtained by using a new design of Pendulum Machine capable of measuring the frictional resistance of a natural or artificial hip joint directly.

USE OF PENDULUM MACHINES

The conclusions of Charnley (1958, 1960a,b) and of Little and others (1969) were based on the decay in amplitude produced by incorporating joints in pendulum machines. From these experiments the workers postulated that the lubrication mode prevailing under these conditions was boundary in nature. This was based on a linear decay in the amplitude of the pendulum with time. By mathematical analysis it will be shown that, even when a full fluid film is present in the joint, the decay in amplitude is still almost linear.

RESULTS OF PENDULUM MACHINE EXPERIMENTS

A pendulum machine has been designed in such a way as to provide a direct measurement of frictional torque from the instant of applying the load (30 to 333 lb./sq. ft). In this way frictional characteristics of human and artificial hip joints have been obtained.

With natural cadaveric joints lubricated with synovial fluid, the mode of lubrication was shown to be mainly squeeze film but at the lower loads (less than 150 lb./sq. ft) evidence of elastohydrodynamic lubrication was also apparent. The coefficient of friction reduced as the load increased.

When natural joints were dried from excessive synovial fluid, the characteristics changed and these followed the pattern of boundary lubricated systems.

Discussion

DR. E. N. GLICK (*London*) Have you done similar measurements in pathological joints?

DR. UNSWORTH Only one so far. The difficulty is the lack of geometrical symmetry that you have in a natural joint and it is very difficult to centralize it in the machine.

DR. A. J. PALFREY (*London*) Could you say how many joints you have examined? If I understand you aright, you believe boundary lubrication comes in under conditions of heavy and prolonged loading and that under smaller loads fluid film lubrication is more important. Is it true that boundary lubrication could contribute to the behaviour of the joint while fluid film lubrication is the more important type of lubrication?

DR. UNSWORTH I've tested about six natural joints and all agree with this pattern. We have only tried the one osteoarthrotic joint. Boundary lubrication I think will be important under conditions of high load and low sliding velocity. Where we have not got high sliding velocity we do not generate sufficient pressure and mathematics show that you therefore cannot generate a good film. So boundary lubrication will be important there. However, I also think that the polar active properties of the boundary lubricant are important during the fluid film stage as well.

DR. A. ST. J. DIXON (*Bath*) Have you estimated whether either of these joints is in fact in the range or near the maximum of what occurs in life?

DR. UNSWORTH In life the maximum load in walking would be up to about four or five times body weight. We have taken a range from about 30 lb. up to about 350 lb. maximum. This is simply because of the limitation of the machine, but this is the range we have taken and I think it is an important range because it appears to cover the point where transition occurs from fluid film to boundary lubrication. I don't think we'll get very much greater change at the higher load.

References

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Survey of Joint Mobility and *in vivo* Skin Elasticity in London School Children. By S. SILVERMAN, L. CONSTINE, W. HARVEY, and R. GRAHAME (*Guy's Hospital Medical School, London, and Johns Hopkins Medical School, Baltimore*)

The survey was conducted in 78 healthy children (39 boys and 39 girls aged between 5 and 11 years) attending a London Primary School. The investigation was carried out with the full consent and co-operation of the children concerned, their parents and the school authorities.

With regard to joint mobility, estimates of the commonly used measurements, *viz.* passive flexion of the wrist and ankle, passive hyperextension of the elbow and knee, were too insensitive to detect any age effect. However, a recently introduced reproducible method of estimating extensibility of the fifth metacarpophalangeal joint in response to a standard load (Grahame and Jenkins, 1972) detected a highly significant inverse correlation between joint mobility and age in the samples tested ($r = -0.586$; $P < 0.0001$). There was no apparent sex difference.

Skin-fold thickness was estimated using a Harpenden Caliper over the third right metacarpal and the *in vivo* skin elasticity was measured using a suction cup device (Grahame and Holt, 1969; Grahame, 1970). No influence of age or sex was apparent on skin thickness or skin elasticity in children, in sharp contradistinction to the effect of both age and sex on these two parameters in adults. Furthermore, no correlation could be established between joint flexibility and either skin thickness or skin elasticity in this study. Ligamentous laxity and skin hyperextensibility concur in certain hereditary disorders of connective tissues, *e.g.* the Ehlers-Danlos syndrome (Grahame and Beighton, 1969). However, in this study of healthy children, no simple relationship was apparent between the restraining effect of joint ligaments on the one hand and resistance to skin stretch (*i.e.* elasticity) on the other, despite the fact that the tensile properties both these tissues devolve almost exclusively on collagen.

Discussion

PROF. V. WRIGHT (*Leeds*) I am interested to know the reproducibility of the goniometer measurements and I wonder if with measuring things at their limit, one is not looking so much at the joint capsule as at the tendon effects? You will remember that when we did some work with the cat wrist joint we found that in the mid-range of motion the joint capsule was the important factor but at the extremes of joint motion the tendons exerted a check-rein effect. May you not be measuring the looseness of the tendons in these subjects?

DR. GRAHAME The goniometer measurements were the results of two independent observers and they correlated very closely. We have carried out similar experiments on cadaveric fingers where the tendons were not operating and we have got almost identical results with the results shown in the slides. Unfortunately time was not available to get them on the slides; the experiments were too recent.

DR. J. T. SCOTT (*London*) I think testing the reproducibility of these situations is difficult. I once did some studies on metacarpophalangeal extensibility and tried to test reproducibility (Scott, 1960), but found that if you kept on waggling the finger it became looser and looser!

DR. GRAHAME As far as the metacarpophalangeal joint is concerned, tests of reproducibility were undertaken in a previous study (Grahame and Jenkins, 1972), and the reproducibility was very high indeed, so I think this can be a very useful test provided one standardizes the load.

DR. D. S. SMITH (*Harrow*) Did you standardize the time of the day that you did these tests?

DR. GRAHAME They were all done during school hours.

DR. A. ST. J. DIXON (*Bath*) Have you any guide for us in trying to assess the progress of the patients being treated with drugs which injure collagen and may affect joint mobility such as steroids and D-penicillamine?

DR. GRAHAME At the moment we have not, but we are in the process of following patients who are taking D-penicillamine.

DR. A. ST. J. DIXON (*Bath*) You are not doing it on the joints?

DR. GRAHAME No, not on these joints.

DR. A. ST. J. DIXON (*Bath*) I should like something like a grip test that one can do quite quickly as a clinical measurement and then use to follow patients over the years.

DR. GRAHAME Might this not reflect the benefit of the drug on their arthritis rather than on their collagen.

References

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Bone Density in Osteoarthritis. By M. V. L. FOSS (*Institute of Orthopaedics, London*)

A study of a metacarpal index of bone density in patients with fracture of the upper end of the femur and with osteoarthritis (OA) of the hip showed, in addition to the expected osteoporosis in fracture cases, an abnormally high bone density in the majority of patients with osteoarthritis. These 100 patients had advanced OA and were undergoing total hip replacement (Foss and Byers, 1972).

This earlier study has now been extended to include 100 patients undergoing osteotomy for OA of the hip. The mean age of this group was some 10 years below that in the first group, and no case was so advanced as to show loss of joint architecture other than joint space narrowing due to cartilage loss.

These two groups showed a very similar pattern of bone density distribution: