Functions of the Menisci. A Preliminary Study. By B. B. SEEDHOM, D. DOWSON, and V. WRIGHT (*Leeds*)

The menisci have always been of interest and there are opposing views regarding their function. On the one hand, they are considered as vestigial structures serving no purpose, and on the other hand a number of important functions have been attributed to them:

- (1) Shock absorption, possibly resulting from the elastic nature of the disc, serving to protect the articular surface.
- (2) Increased congruity between the articular surfaces, thereby improving joint stability.
- (3) Permitting motion of bones relative to a joint-dividing disc as well as relative to each other.
- (4) Acting as a chock to prevent undue forward gliding, as in the knee of the femur on the tibia.
- (5) Ball-bearing action, facilitating rolling forward of the lateral femoral condyle as the femur rotates medially at the end of extension.
- (6) Improvement of weight distribution by enlarging the effective contact area between the bones.
- (7) Protection of the joint margin, particularly in the case of the menisci which slide backwards in flexion, thus protecting the posterior margin of the tibial articular surface.

There are reasons to believe that one of the most important functions is load-bearing, and this paper presents experimental evidence to demonstrate this and to quantitate the fraction carried by the menisci of the load acting on the joint.

Experiments were carried out on young cadaveric knees, at full extension. First the knee was compressed in a universal Instron machine, and the approximation of the condyles, on both sides, was measured. For this two displacement transducers were employed, one on each side of the knee. The armature of the transducer was attached to the femur and the cam to the tibia. Two $x-y$ plotters were used to record the load displacement curves on both sides. The load that was applied on the knee was slowly increased by 2 kg. to 100 hg. The menisci were then made redundant by dividing their anterior attachments to the tibia and the experiment was repeated. On comparing the load displacement curves before and after dividing the meniscal attachments, it was possible to determine the load carried by the menisci. The results showed that they carry a considerable share, the lateral meniscus 70 per cent and the medial meniscus 50 per cent of the load acting on the respective sides of the joint. As a result, the stresses occurring in the knee are low and comparable with those occurring in the hip under the similar conditions of loading. The fact that the menisci have a load-bearing function has other implications. The congruity they add to the joint increases the time of approach of the condylar surfaces to 30 to 60 times its value, based on the assumption that they do not carry load. Previous work has shown this value to be 90 seconds. This means that the bearing surfaces of the joint will not come into contact after long periods of standstill. This is a desirable situation as it is known that wear in lubricated bearings takes place during the starting phase, when the surfaces are in contact, and ceases during the running phase, in which the surfaces are separated by a lubricant film.

Discussion

DR. A. J. PALFREY (*London*) In my experience there is a good deal of variation in the area of the lateral meniscus. Have you related this to the load transmitted through the meniscus in the individual specimen? Secondly, would you agree that the menisci are virtually inextensible along their length? Thirdly, the surface of the meniscus in a histological preparation is much less smooth than the surface of articular cartilage: is this partly responsible for the long squeeze-film time?

DR. SEEDHOM Concerning the area of the lateral meniscus; we thought of it as a fraction of the total area of the lateral condyle. The 'bare' area of the articular cartilage of the lateral tibial condyle is nearly one-third that of its total area, so that the lateral meniscus covers about two-thirds of it; thus when the menisci are there they increase the load-carrying area to three times what it would be if they were not there.

Secondly, we have used fresh material—we have not fixed the knees—in fact when an experiment was conducted we tried to carry it out in a very short time and if the joint had to be left out for any length of time it was enclosed in a polythene bag or a wet cloth with isotonic saline wrapped round it until the rest of the apparatus was set up.

Now, concerning your final point, the synovial fluid will be trapped between the undulating surface of the articular cartilage and the less undulating surface of the meniscus. It will experience resistance in being squeezed out. I do not know how different the squeeze-film time will be in this case compared with the case of two equally undulating surfaces of articular cartilage in contact.

DR. M. I. V. JAYSON (*Bath*) Can I ask you about the visco-elastic properties of the cartilage and bone in your experiments? Was there any residual deformation after you applied loads up to 100 kg. on dead tissue in this way? Did you repeat the same experiment several times to see if you got any change in the shape of the stress/strain curves?

DR. SEEDHOM The load increased from 2 to 95 kg. and then decreased to 2 kg. The cycle was repeated and a similar load-displacement curve was obtained. Sometimes there was a residual displacement but, compared with the total displacement, it was as little as 5 per cent so that you can neglect it.

DR. A. ST J. DIXON (*Bath*) I wonder if you think the state of the biomedical art is now such that by engineering you could put strain gauges on to these little prostheses?

DR. SEEDHOM It has been done with the hip, probably by Rydell (1966). He had an Austin Moore prosthesis with a modified neck (hollow and thin-walled), inside which he put two strain gauges so that he could measure the force acting on the femoral head directly. But I think the situation is very much more complex in the knee, because there is no equivalent feature in thin knee prostheses where you could attach a couple of strain gauges and have wires coming out of the knee. That might reduce the strength of the fixation of the component. Also, to have wires coming out of the knee joint which is 'skin deep' might increase the hazard of infection. The remedy of this is perhaps to use a telemetric load cell enclosed in a very small capsule, but even then the fixation strength might be affected.

Reference
Rydell, N. W. (1966) *Acta orthop. scand.*, 37, Suppl. 88, 'Forces acting on the femoral head-prosthesis.'