JOINT PROPRIOCEPTION IN NORMAL, OSTEOARTHRITIC AND REPLACED KNEES

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We measured joint position sense in the knee by a new method which tests the proprioceptive contribution of the joint capsule and ligaments. The leg was supported on a splint, and held in several positions of flexion. The subjects' perception of the position was recorded on a visual analogue model and compared with the actual angle of flexion. Eighty-one normal and 45 osteoarthritic knees were examined, as were 10 knees with semi-constrained and 11 with hinged joint replacements. All were assessed with and without an elastic bandage around the knee.

There was a steady decline in joint position sense with age in subjects with normal knees. Those with osteoarthritic knees had impaired joint position sense at all ages ($p < 0.001$). Knee replacement improved the joint position sense slightly ($p < 0.02$); semi-constrained replacement had a greater effect than hinged replacement.

The effect of an elastic bandage in subjects with poor position sense was dramatic, improving accuracy by 40% ($p < 0.001$).

It is proposed that reduced proprioception in elderly and osteoarthritic subjects may be responsible for initiation or advancement of degeneration of the knee.

Neuropathic joints, first described by Charcot in tabetic patients, have since been reported in a variety of other conditions such as diabetes, syringomyelia and congenital absence of pain (Jordan 1936). Neurological abnormalities are suspected wherever Charcot joints are present. The classical changes of disorganisation, fragmentation and massive osteophyte formation with destruction of subchondral bone are seen both in Charcot's joints and in Charcot-like hypertrophic osteoarthritis (Eichenholtz 1966). The role of neuropathy in the development of destructive changes in weight-bearing joints is unclear and the relative importance of loss of pain and loss of proprioception is ill-defined.

In the absence of the protective sensation of pain, joint trauma and small fractures are not appreciated and the articular surfaces degenerate. Lack of proprioceptive sensation causes altered gait and unphysiological joint loading; slowly progressive joint degeneration may follow. Both altered gait and disturbed joint loading occur in patients with osteoarthritis (Stauffer, Chao and Györy 1977).

Contrary to popular belief, the majority of patients with Charcot joints have considerable pain. Whether this pain is a useful somatic sensation affording protection or an autonomically mediated ache is not known. Tabes dorsalis definitely affects the posterior columns rather than the spinothalamic tracts. However, in the sensory radicular neuropathy described by Denny-Brown (1951), patients maintain good joint position sense whilst losing the sensation of pain; proprioception remains intact and destructive change in the joints do not occur (Greider 1983). Furthermore, interruption of the pain pathways in experimental animals has failed to produce neuropathic joint disease (O'Connor, Palmoski and Brandt 1985).

To what extent, therefore, does lack of good proprioception predispose to the development of degenerative change? Many features of 'neuropathic joint disease' are similar to those seen in osteoarthritis (Katz, Rabinowitz and Dziadiw 1961; Johnson 1967). Skinner, Barrack and Cook (1984) demonstrated progressive deterioration of proprioception with increasing age, but their method involved the active movement of the joint by the subject, testing position sense not only from the joint surfaces, capsule and ligaments but also from the stretch receptors in tendons and muscles.

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We have attempted to measure position sense as mediated solely by the joint structures. We employed a new method which excluded some of the effects of muscle tension, cutaneous sensation and the appreciation of gravity.

PATIENTS, MATERIALS AND METHODS

Patients. The subjects were all volunteers from the staff or the patients of the Royal National Orthopaedic Hospital.

We excluded from the study any subjects with:
1) neurological disease, such as CVA, Parkinson's disease or dementia;
2) metabolic or vascular disease with a neurological component, such as diabetes or atherosclerosis;
3) previous knee operations other than joint replacement in the patient group;
4) recent significant injury to the knee, femur or tibia.

Both legs of each subject were examined; the measurements were repeated later with an elastic bandage around the knee.

Apparatus. A Thomas splint with a Pearson knee-flexion piece was modified to provide well-padded support to the whole leg, with its axis of flexion close to the axis of the knee. A protractor attached to the splint measured the angle (Θ) subtended by the Pearson knee piece as it was moved by an observer in the range 0° to 30° (Fig. 1).

The patient lay supine on a couch with one leg supported in the splint; a screen prevented any visual clues as to the position of the limb. The leg was moved passively to 10 different predetermined positions of flexion. The subject represented the perceived angle of flexion on a visual analogue model (Fig. 1). The measurement of inaccuracy was the difference between the perceived angle and the actual angle of flexion.

Method. A total of 147 knees were examined. The age of the patients ranged from 16 to 86 years; 51% were male and 49% female. Having established the reliability and reproducibility of measurements, we compared the quality of joint position sense in three groups:
1) normal subjects of various ages;
2) patients with radiologically proven osteoarthritis;
3) patients who had undergone total knee replacement.

Lastly, we tested the effect on proprioception of a simple elastic bandage applied to the knee as tightly as was comfortable; the aim was to maximise the cutaneous sensation of joint position.

The results were subjected to multivariate regression analysis.

RESULTS

In normal subjects the error measured between the real and the perceived angles of flexion varied from 0° to 18° (Fig. 2). Performance in this test did not vary between left and right knees or between male and female. Results

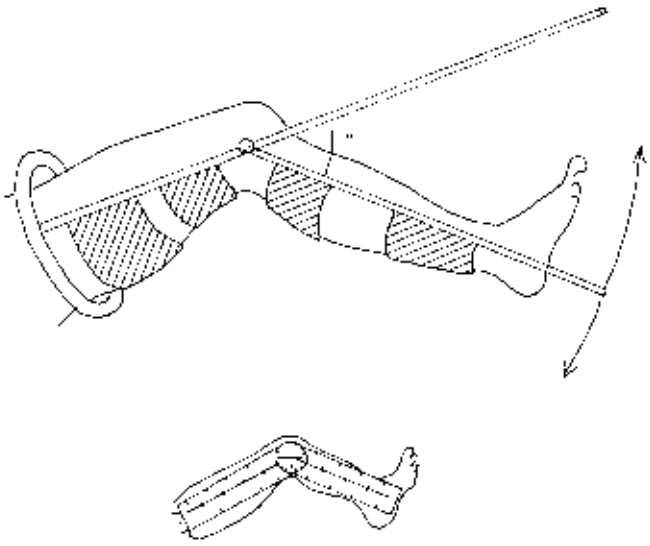

Fig. 1

Apparatus to support the leg and measure knee flexion (top). Visual analogue model of leg incorporating goniometer (bottom).

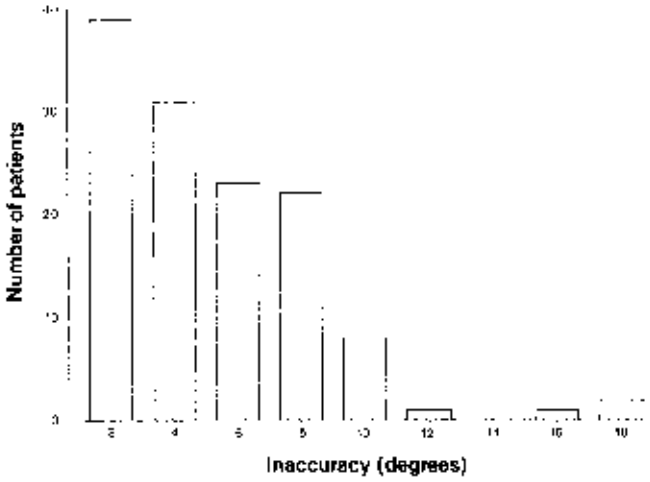

Fig. 2

Measured inaccuracy of joint position sense in normal subjects.

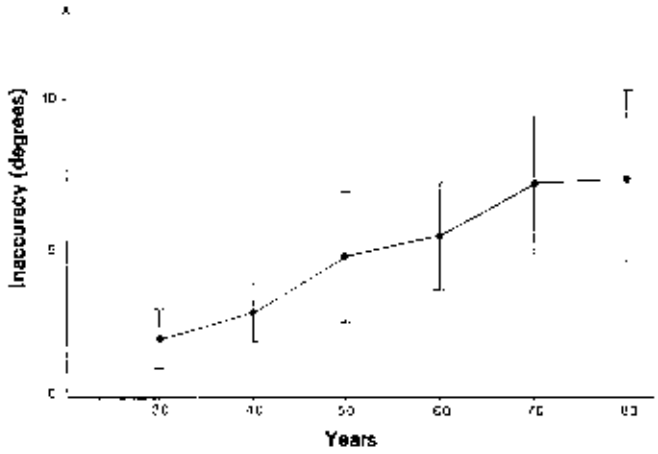

Fig. 3

Measured inaccuracy of joint position sense by age (81 knees).

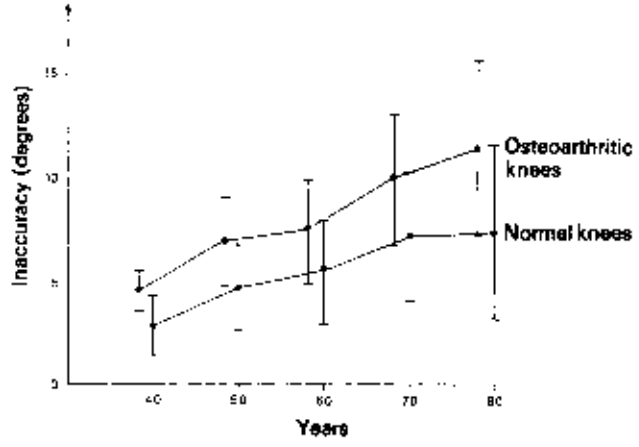

Fig. 4

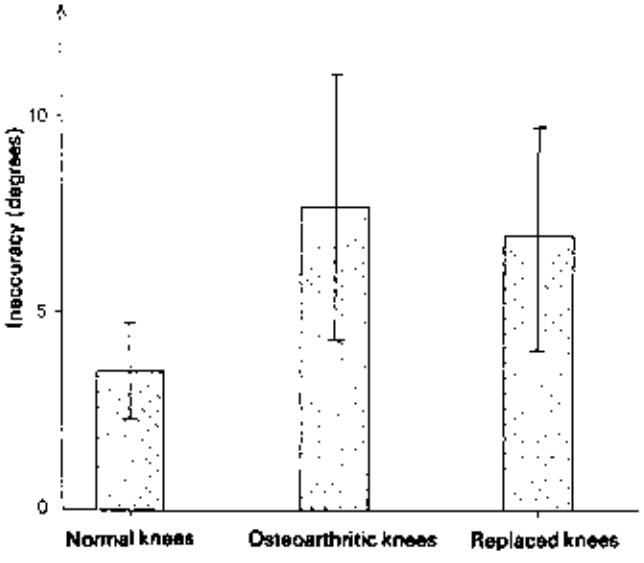

Fig. 5

Figure 4 – Measured inaccuracy in osteoarthritic patients (45 knees) and normal subjects (81 knees). Figure 5 – Measured inaccuracy corrected for age in normal, osteoarthritic and replaced knees.

were reproducible and consistent with subsequent tests on the same subjects.

There was a trend toward greater accuracy in observations made later in each assessment, suggesting some form of learning process, but this trend did not achieve statistical significance. It was taken into account in all comparisons.

Normal knees. The effect of age in normal subjects was to produce a poorer average performance ($p < 0.01$, by linear regression analysis) and the range of accuracy in the older age group was wider (Fig. 3).

Osteoarthritic knees. The patients with osteoarthritic knees showed less accuracy in position sense compared with normal subjects ($p < 0.001$, Figs 4 and 5).

Replaced knees. Patients with total knee replacements (Fig. 5), exhibited greater accuracy than did those with osteoarthritic knees ($p < 0.02$).

Comparison of the performance of patients with semi-constrained knee replacements (Insall/Burstein Posterior Stabilised, Johnson and Johnson, n = 10) and constrained prostheses (Stanmore hinge, Biomet, n = 11) favoured the former (Fig. 6). This trend did not achieve statistical significance.

Elastic bandage. The effect of wearing an elastic bandage was to improve accuracy significantly ($p < 0.001$) in all subjects with impaired joint position sense (Fig. 7). No improvement in accuracy was detected in those with good joint position sense.

DISCUSSION

The changes of osteoarthritis are brought about by a mechanism or mechanisms which are still unclear. In the hypertrophic arthritis of Charcot joints, the loss of pain and proprioception are important in initiation and progression of the disease. However, similar degenerative

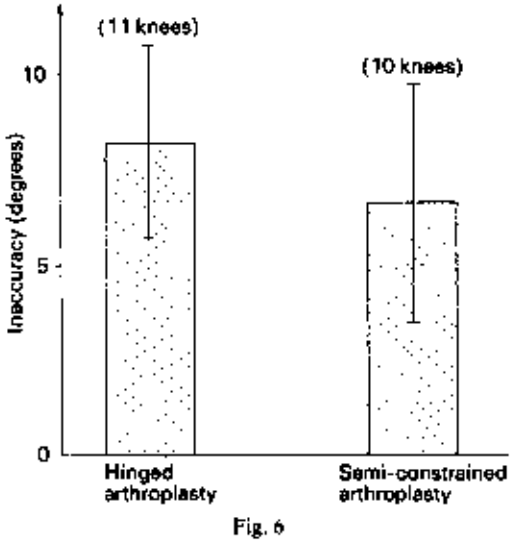

Fig. 6

Measured inaccuracy corrected for age in hinged (Stanmore) and semiconstrained (Insall–Burstein) knee replacements.

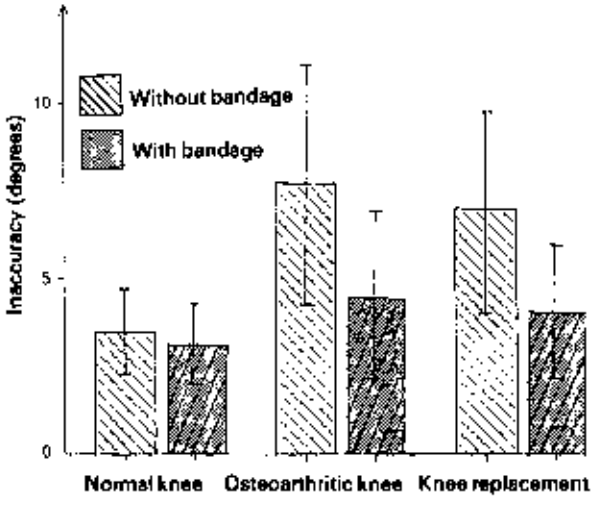

Fig. 7

The effect of an elastic bandage on measured inaccuracy in normal, osteoarthritic and replaced knees (corrected for age).

changes occur in syndromes in which only proprioception is lost (Denny-Brown 1951; Greider 1983); in the Charcot-like joints of hypertrophic osteoarthritis pain sensation is fully present. It appears that loss of proprioception may therefore play the major role.

Our study has shown that joint position sense is less accurate in older normal subjects. This might explain the change in gait patterns in normal ageing even in the absence of any signs or symptoms of osteoarthritis (Murray, Kory and Clarkson 1969). The abnormal wide-based gait of the osteoarthritic patient is not necessarily related to the pain experienced. Stauffer et al (1977) suggested that loss of proprioception might be the major factor, and that the abnormal gait is an effort to maximise proprioceptive input. The results of our study support this view.

Patients with osteoarthritis showed poorer joint position sense than those of a similar age with no joint disease. Some loss of proprioception might be expected as a result of laxity of the capsule and ligaments caused by loss of cartilage and bone height. It is also possible that lytic enzymes released around the joint may cause damage to the receptor end-organs within the capsule.

Though loss of joint position sense may be a consequence of the process of osteoarthritis, it may equally be a primary factor in the initiation of joint damage. We have shown that when joint alignment and 'joint space height' are restored by replacement arthroplasty, joint position sense improved. However, this recovery did not reach the accuracy of proprioception of age-matched patients with normal knees. Perhaps only a part of the deficit in joint position sense is attributable to joint damage and other factors may be involved.

If, indeed, patients with semiconstrained total knee replacements do have better joint position sense than those with hinge replacements, the importance of receptors within the joint capsule and ligaments would be confirmed. These structures remain intact around the semiconstrained implant, but are removed during insertion of a hinged prosthesis. Knees with intact joint position receptors may suffer less traumatic loading which may be important in preventing the long-term loosening and wear of prosthetic components.

An elastic bandage around the knee improved the performance of patients with poor joint position sense. These bandages provide little or no mechanical support to the knee, yet the feeling of improved stability has often been reported by those with arthritis and by sportsmen with ligament injuries. We now have objective evidence that wearing a bandage improves joint position sense in knees in which it is impaired.

It is not possible from this study to conclude whether loss of joint position sense causes osteoarthritis or is a consequence of it. We have shown an age-related decline in proprioception as have others by different methods (Skinner et al 1984). Histological and histochemical changes in articular cartilage associated with ageing are also found in degenerative joint disease. These age-related changes may be multifactorial but it is interesting to note that sensory denervation of joints produces degeneration of chondrocytes at the cartilage surface (Finsterbush and Friedman 1975), which is similar to that ascribed to age (Barnett, Cochrane and Palfrey 1963). Thus, loss of proprioception may be related to degeneration of the joint surfaces at both the biomechanical and the cellular level.

Conclusions

1) our method of measuring knee position sense is reliable and reproducible;

2) knee position sense deteriorates with age;

3) joint position sense is impaired in osteoarthritic knees; and

4) wearing an elasticated bandage around the knee improves joint position sense where this is deficient.

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