Injuries to the sciatic nerve are an occasional complication of surgery to the hip and acetabulum, and traction is frequently the causative mechanism. In vitro and animal experiments have shown that increased tensile strain on peripheral nerves, when applied for prolonged periods, impairs nerve function.

We have used video-extensometry to measure strain on the human sciatic nerve during total hip replacement (THR). Ten consecutive patients with a mean age of 72 years undergoing primary THR by the posterior approach were recruited, and strains in the sciatic nerve were measured in different combinations of flexion and extension of the hip and knee, before dislocation of the hip. Significant increases (p = 0.02) in strain in the sciatic nerve were observed in flexion of the hip and extension of the knee. The mean increase was 26% (19% to 30%). In animal studies increases of this magnitude have been shown to impair electrophysiological function in peripheral nerves. Our results suggest that excessive flexion of the hip and extension of the knee should be avoided during THR.

Patients and Methods

We used video-extensometry (Messphysik Laborgeraete GesmbH, Furstenfeld, Austria) to measure strain on the human sciatic nerve in vivo during THR. The apparatus consists of a high-resolution camera linked directly to a desktop computer terminal. Mechanical strain is measured in real time as an alteration in the distance between markers on the test material relative to the original distance. The technique has not previously been used to measure strain in biological tissues, but has been used for very precise measurements of strain in industrial materials.

We recruited ten consecutive patients presenting for primary THR. There were five men and five women with a mean age of 72 years (60 to 78). Patients with limb-length discrepancies or hip dysplasia were excluded. It was felt that variables in these patients may confound the results. In patients with uncomplicated primary osteoarthritis any observed differences in nerve strain were more likely to be due to movement of the hip and knee alone. Informed consent was given by all the patients.

The posterior approach was used in all operations. Before dislocation of the hip the sciatic nerve was exposed and resting strain measurements were made. Perineural fat was removed over a short portion of the nerve, at the level of the hip, and three or four transverse target markings were made on the epineurium using a sterile surgical marker. The
camera, mounted on an overhead beam, was focused on the markings, and the video output was fed to a computer by dedicated software (Video-extensometer for Windows Version v4.06; Messphysik Laborgeraete GesmbH) in order to calculate strain. Resting readings were made with the hip extended at neutral and the knee flexed to 90˚. With both neutral hip extension and 45˚ of flexion of the hip, we measured the effect on the sciatic nerve of extending the knee from 90˚ to zero flexion. A goniometer was used to measure the movements. For flexion of the hip the limbs of the goniometer were aligned with the femoral shaft and the axis of the trunk and for flexion of the knee they were aligned along the palpated axes of the femur and tibia.

**Statistical analysis.** We used Sigma-stat computer software (Jandel Scientific, San Rafael, California). A paired Student two-tailed t-test determined the significance of differences observed in the effect of extension of the knee.

**Results**

In no patient did the investigation adversely affect the function of the sciatic nerve postoperatively. It added approxi-
mately five minutes to the operating time. There were no significant differences in the results between men and women. Extension of the knee with the hip extended caused a mean increase in strain on the nerve of 14% (10% to 19%), whereas extension of the knee with the hip flexed to 45° caused a mean increase in strain of 26% (19% to 30%). This difference was statistically significant (p = 0.02; Figs 1 and 2).

Discussion

Nerve damage is an acknowledged complication after THR, with a reported incidence of injury to the sciatic nerve of up to 1.7% after primary THR. Postoperative electrophysiological studies suggest that the incidence of subclinical damage may be higher. An incidence of 5.2% has been reported after primary THR undertaken for congenital dislocation or dysplasia of the hip, and 3.2% after revision surgery. Traction on the sciatic nerve is assumed to be one of the mechanisms underlying these injuries. Our study demonstrates the changes in strain which occur in vivo in the human sciatic nerve.

The role of intraoperative somatosensory evoked potentials (SSEPs) and electromyography (EMG) has been investigated in regard to the prevention of iatrogenic nerve injury during internal fixation of acetabular fractures. We know of no attempt, however, to correlate electrophysiological changes with strain in the sciatic nerve. In vitro and animal experiments show that peripheral nerves are non-homogeneous, viscoelastic tissues with unique mechanical characteristics. They have non-linear stress-strain characteristics when subjected to tensile forces. Under tension a nerve initially has a low elastic modulus which increases gradually with increasing strain until it reaches a maximal value. Brown et al examined the effect of acute stretch on the electrophysiological properties of the rabbit peripheral nerve, and concluded that both the amount and duration of strain affected the compound motor action potentials. They demonstrated that strain of 8% for two hours did not significantly decrease the amplitude of compound motor action potentials, but that of 15% resulted in a profound fall (99%).

Our study has shown that significant increases in strain in the sciatic nerve occur within a physiological range of movement during THR. These increases reach the levels defined in animal experiments as potentially damaging to the function of the peripheral nerve. In flexion of the hip and extension of the knee, strain in the sciatic nerve increased by up to 30% with a mean increase of 26%. Although none of the patients in our study had problems with the sciatic nerve postoperatively, the available evidence suggests that this degree of strain in animal experiments diminishes nerve function when maintained over a prolonged period. This should be borne in mind by surgeons and assistants during THR and during surgery to fix fractures about the hip and acetabulum.

There are limitations to our study. Our measurements strictly assess changes in strain in the epineurium. It is not possible to interfere with the structure of the sciatic nerve in human in vivo experiments. We believe that these measurements accurately reflect changes in the nerve, and that exposure and marking of the individual nerve bundles would have been dangerous. We imposed time restrictions on our video assessments to minimise the risk of damaging the nerve and unduly prolonging the operation. These restrictions precluded measurement of the degree of stress relaxation in the sciatic nerve in vivo, which has been shown to occur in animal studies. We did not correlate changes in strain over time with SSEPs or EMG. Nevertheless, animal experiments reported in the literature support our contention that the changes in strain which we observed were significant. It should also be borne in mind that biological tissues show changes in their elastic modulus with ageing. All patients in our study were elderly and it is not possible to extrapolate the measurements in younger individuals. Our data were drawn, however, from typical patients undergoing primary THR.

The positions of the hip and knee in which increased strain in the sciatic nerve were measured were well within a normal range of movement, raising the question as to why neuropathic changes do not develop under normal circumstances. We suggest that normal subjects do not maintain the hip-flexed/knee-extended position for prolonged periods with comfort, and subconsciously adjust their posture accordingly. Crucially, these protective proprioceptive reflex mechanisms may be absent in anaesthetised patients, and postoperatively while spinal anaesthesia persists.

Our study has shown that video-extensometry is a safe, non-invasive method for quantifying strain in biological tissues in vivo. These findings should be borne in mind during THR in order to minimise the incidence of iatrogenic damage to the sciatic nerve.

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References