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Acute effects of hip and knee positions on motor-evoked potentials of the sciatic nerve in total hip arthroplasty

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Abstract In 23 patients, motor-evoked potentials (MEP) of the sciatic nerve were elicited during total hip arthroplasty by using a stimulating electrode at the level of the acetabulum and recording from the middle portion of the tibialis anterior. The distal motor latencies were determined before dislocation (control), during dislocation, and after reduction with the trial prosthesis. While the hip was dislocated, recording was performed at varying angles of the hip and knee joints. During dislocation, the distal motor latencies were significantly increased in all positions except at hip flexion of 60° and internal rotation of 60° with the knee joint in maximum flexion. No significant correlations were found between the latency increase and limb lengthening. No patient had sciatic nerve palsy or causalgia after operation.

Résumé Chez vingt-trois malades, les potentiels moteurs évoqués du nerf sciatique ont été étudiés pendant l'arthroplastie totale de la hanche en utilisant une électrode stimulant au niveau de cotyle et en enregistrant la portion centrale du muscle tibial antérieur. Les latences motrices distales ont été déterminées avant la luxation (contrôle), pendant la luxation, et après réduction avec la prothèse d'essai. Pendant que la hanche était luxée, un enregistrement a été exécuté à angles variables de la hanche et du genou. Pendant la luxation les latences motrices distales ont été augmentées dans toutes les positions excepté celle avec flexion de la hanche à 60° et rotation interne de 60° et genou en flexion maximale. Aucune corrélation notable n'a été trouvée entre l'augmentation de latence et l'allongement du membre. Aucun malade n'avait de paralysie du nerf sciatique ni de causalgie après l'opération.

Introduction

The incidence of sciatic nerve palsy, a serious complication of total hip arthroplasty (THA), is reported to be from 0.28% to 3.0% in primary THA and from 2.6% to 7.6% in revision THA [1, 2, 5, 11]. Various contributing factors of this complication have also been described [2, 4, 7, 9, 10]. In previous reports, somatosensory evoked potentials (SEP) were utilized for monitoring sciatic nerve function during surgery [1, 3, 5, 8, 11]. The monitoring of SEP is a useful and noninvasive method for intraoperative investigation of nerve function, though, occasionally, baseline SEP recordings cannot be obtained due to the complexity of the data. Furthermore, various factors in addition to the condition of the sciatic nerve itself can affect SEP, largely due to the fact that the recording electrode is usually placed on the head (Cz). In this report, motor-evoked potentials (MEP) were utilized to evaluate motor function specifically of the sciatic nerve. Furthermore, the effects of hip and knee positions on sciatic nerve motor function during the dislocation of the hip that occurs during THA have not been previously described and are as yet unknown. The purposes of this study were to evaluate the effect of the hip and knee positions on sciatic nerve motor function, and to clarify those hip and knee positions that might facilitate more effective prevention of sciatic nerve palsy during hip dislocation in THA.

Patients and methods

Twenty-three patients (18 women and five men) were examined in this study. Mean age at the time of operation was 63 (range 37–84) years. Twenty-one patients had primary THA and the remaining two had revision THA. All procedures were performed with the patient in the lateral decubitus position, through a posterolateral approach, and by a single surgeon. Epidural anesthesia was administered to all patients. No trochanteric osteotomies were performed.

An MEB-9100 system (Nihon Kohden, Tokyo, Japan) was used to record all electrophysiological data. The stimulating electrode was placed directly on the sciatic nerve at a level just poste-

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Fig. 1 Schematic diagram for the anatomic location of the three electrodes used for monitoring motor-evoked potentials (MEP). The stimulating electrode was placed directly on the sciatic nerve at a level just posterior to the acetabulum, and the MEP were recorded from the middle portion of the tibialis anterior

rior to the acetabulum, and the recording electrode was placed at the middle portion of the tibialis anterior. The ground electrode was placed on the opposite planta (Fig. 1). In all cases, stimulation at an intensity of 5 mA for a duration of 0.2 ms at a frequency of 1 Hz was delivered. Distal motor latencies of the sciatic nerve were recorded before dislocation with the hip and knee joints in neutral (control), during dislocation after cutting the femoral neck and with the hip and knee in various positions, and after reduction with the prosthesis attached and the hip and knee joints in neutral. During dislocation, five recordings were obtained for each patient, with the hip and knee joints in the following positions: (1) hip joint at 60° of flexion and 60° of internal rotation, and knee joint at 0° of flexion; (2) hip joint at 60° of flexion and 60° of internal rotation, and knee joint at 60° of flexion; (3) hip joint at 60° of flexion and 60° of internal rotation, and knee joint at 90° of flexion; (4) hip joint at 60° of flexion and 60° of internal rotation, and knee joint at maximum flexion; (5) hip joint at 60° of flexion and maximum of internal rotation, and knee joint at 90° of flexion. The order of the recordings was randomized. Mann-Whitney *U*-test was used to determine significant changes in latency.

A simple method was used to evaluate limb lengthening from a single standard AP view of the pelvis. Horizontal lines passing through the inferior aspect of the teardrop were drawn. The vertical distance between the most prominent point of the lesser trochanter and the transteardrop line was measured using 10% magnified templates. These measurements were made on preoperative radiographs, and on postoperative radiographs obtained at an average of 7 days after surgery. To determine the correlation between latency increase and limb lengthening, Pearson's correlation coefficient was used.

Results

Distal motor latencies were increased significantly in all positions, except that in which the hip joint was at 60° of

Fig. 2 Changes in distal motor latencies for various hip and knee positions. Significant increase in latencies were recorded for all positions, excepting that in which the hip joint was at 60° of flexion and 60° of internal rotation and the knee joint was at maximum flexion, as compared with the control

flexion and 60° of internal rotation, and the knee joint was at maximum flexion during dislocation, as compared with the control value (Fig. 2). Mean leg lengthening was 12.73 (range 0–34.5) mm, and no obvious correlation between latency increase and limb lengthening was observed (Fig. 3a and b). No patient had sciatic nerve palsy or causalgia after operation.

Discussion

Monitoring SEP is a well-established method for detecting neurological disorders during operation. In all previous reports, excepting one by Kennedy et al. [5], the stimulating electrode was placed in the fibula head, and SEP were recorded from the head (Cz). By this method, other factors such as spinal cord degeneration may affect the results [1, 3, 8, 11]. In the present study, the locations of the stimulating point and the recording point appear to be more reasonable for monitoring the sciatic nerve than those of ordinary monitoring using SEP because the measured area would be restricted and would correspond more specifically to the sciatic nerve. Furthermore, by using direct stimulation of the sciatic nerve, recordings of MEP were easily obtained on each stimulation and were reproducible and stable. Moreover, functional impairment resulting from sciatic nerve palsy is mainly due to motor loss in the lower limb. The monitoring of distal motor latency may provide more specific evaluation of sciatic nerve motor function.

The criteria for nerve compromise suggested by other investigators has included a 50% reduction in amplitude of SEP. Black et al. [1] found that the amplitude measurements were variable, and that factors such as patient temperature, blood pressure, anesthetic level, and electrical interference in the operating room, could all affect amplitude. Accordingly, we measured changes in latencies utilizing MEP. All stimulations were delivered at 5 mA in-

Fig. 3 **a** Correlation between latency increase and limb lengthening. No significant correlations were demonstrated ($p=0.132$; $r=0.324$). **b** Motor-evoked potentials (MEP) of the sciatic nerve. MEP recorded from the sciatic nerve during total hip arthroplasty in a 37-year-old man. Latency after reduction was increased by 12.6% as compared with that before dislocation. In this case, limb lengthening was 6.4 mm

tensity. Supramaximal stimulation is generally desirable, but 5 mA was sufficient to obtain stable and reproducible MEP in this study. Therefore, this intensity was used so that the operation time would not be prolonged.

Given that no obvious correlation between latency increase and limb lengthening was observed, the motor nerve function seemed to be vulnerable and to vary on a case-by-case basis. Further studies are needed to clarify the influence of limb lengthening on motor nerve function.

Black et al. [1] reported that SEP were affected when the hip was in extreme internal rotation during femoral

preparation during THA. However, they did not mention whether any changes in latency were associated with knee positions. Three of the current authors [6] previously investigated the effect of hip and knee positions on blood flow in canine sciatic nerve. They concluded that blood flow decreased as hip flexion and internal rotation increased, and also decreased with a smaller flexion angle of the knee. In their study, however, the measurements of blood flow were not performed during dislocation of the hip; thus, there was no hypermobility of the hip joint such as that which occurs during dislocation. They also referred to structural differences between humans and canines. In the current study, motor latencies did not increase with the hip joint at 60° of flexion and 60° of internal rotation and the knee joint at maximum flexion, whereas they significantly increased for all five of the other positions involving the hip and knee joints. From these data, it seems important to keep the knee joint at flexion over 90° while the hip is dislocated during THA in order to reduce potential damage to the sciatic nerve.

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