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博 士 論 文

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人工股関節置換術が股関節位置覚に及ぼす影響に関する研究
前向き研究

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中 川 法 一

Deterioration of position sense at the hip joint following total hip arthroplasty. A prospective time course study

Norikazu Nakagawa

The purpose of this study was to clarify the effects of total hip arthroplasty on joint position sense at the hip. Firstly, 17 cases of postoperative dislocation were investigated retrospectively. The postoperative dislocation was classified as early or late depending on the interval after surgery. All cases (7/7) of late dislocation were clearly aware of their leg position at dislocation, while 40% cases (4/10) of early dislocation could explain their leg position at dislocation precisely. Secondly, 108 patients who had THA were investigated prospectively to clarify whether joint position sense at the hip was restored at 4 weeks after surgery. Using a goniometer for the hip, the patients' hips were passively rotated in the chair sitting position and rotation angles were measured every week when they detected as rotationally neutral (0°). As a result, a significant shift to the internally rotated position was observed between the first 1 to 2 weeks and the next 3 to 4 weeks ($p<0.01$~$p<0.05$). There was no significant relation between the detected angle and either their age or amount of leg lengthening. These results may suggest that intensive care should be taken for early dislocation especially during 2 weeks postoperatively.

Key Words: Hip joint, Total hip arthroplasty, Position sense, Dislocation

Introduction

In recent years, total hip arthroplasty (THA) has been widely performed with the advent of medical engineering. THA has been developed by Sir John Charnley as a trump of function improvement of serious disability in the hip joint [1]. The operation could markedly release patients from pain and impairment, although it requires a compensatory loss of another part of the living body to a large extent. Sensory receptors for joint movement were suggested to be Ruffini ending in the joint capsule, Golgi tendon organ in joint ligaments and muscle spindles [2, 3]. These soft tissues around the hip joint are invaded largely and the joint capsule in which sensory receptors exist is

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extensively removed by THA. It can be assumed that the accuracy of joint position sense decreases following THA. Thus, swift detection of unacceptable leg positions leading to dislocation and integrated movement of the hip joint could be hampered by deteriorated joint position sense following THA.

However, repair processes normally occur in hip muscles and the joint capsule after surgery. In addition, it was reported that a living body has an ability to learn in order to avoid shock even after interception of sensory feedback [4]. In view of these factors or findings, it can be postulated that the serious deterioration of joint position sense might be a temporary phenomenon even though it occurs during the early postoperative period. However, it has not yet been clarified how early joint position sense could be restored following THA.

In this study we performed two examinations to clarify deterioration of joint position sense after THA. One was a retrospective study on dislocated cases regarding how precisely they can be aware of leg position leading to index dislocation. The other was a prospective time course study on joint position sense at an early postoperative period (from 1 to 4 weeks) after THA.

Materials and Methods

1) The retrospective study concerning the incidence and awareness of dislocation after THA

There were 847 patients who received THA at our institution between July 1, 1994 and June 30, 2002. Based on the records of all patients during hospitalization and the out-patient clinic thereafter, 17 patients were identified to have experienced dislocation after surgery. The rate of postoperative dislocation was 2.0%. Regarding the 17 dislocated patients, the situation and the leg position when dislocation occurred, were carefully investigated by direct inquiry for each patient. All the subjects were adequately educated about the leg position leading to dislocation before and after surgery.

2) The prospective study of joint position sense after THA

One hundred and eight patients with osteoarthritis of the hip who had THA at our institution between January 1, 2001 and August 31, 2002 were investigated on position sense of the hip joint. The subjects were not informed of the purpose or the results of the present study. The age (mean ± SD) of the subject was 60.5 ± 8.0 years old (range, 33-77). The operation manner was unified to the posterolateral approach by which posterior joint capsule is entirely removed. For all subjects, the acetabular and femoral components were fixed without bone cement. The prosthesis used in the operation was the Spongiosa Metal II Hip Prosthesis (ESKA, Lübeck, Germany).

The following patients were excluded from this study; those who had neuromuscular disease such as Parkinson's disease, those who

could not assume a complete position for measurement due to pain or extreme restriction of range of motion (internal and external rotation is less than twenty degrees), and those who could not adequately understand the measurement manner.

A goniometer specially made for this study was used for measurement (Fig. 1A). This apparatus consisted of two major parts. One part was manually movable, which consisted of a thigh cuff, a vertical arm, a foot trap and a measurement indicator. The other part consisted of the protractor plate on which the thigh cuff was connected, and a fixation plate that stabilizes the whole measurement apparatus in the horizontal position.

Passive motion was selected to prevent information on position sense from active muscle contraction. Passive movement of rotation was measured in the chair sitting position (Fig. 1B). The reasons why the chair sitting position was selected are as follows: (1) Fixation of pelvis and the restriction of compensatory motion by the pelvis can be achieved more easily in the sitting position than in supine or standing. (2) The tension of the iliofemoral ligament becomes loose in the sitting position, and the information on position sense from the ligament will be minimized.

The test of joint position sense was performed by a method assessing whether or not the subjects detected the neutral position of hip rotation in passive movement. Each subject was tested weekly from the 1st to 4th week after surgery. The measurement was performed by two persons; one person was in charge of passive movement and the other person was in charge of recording. The person in charge of

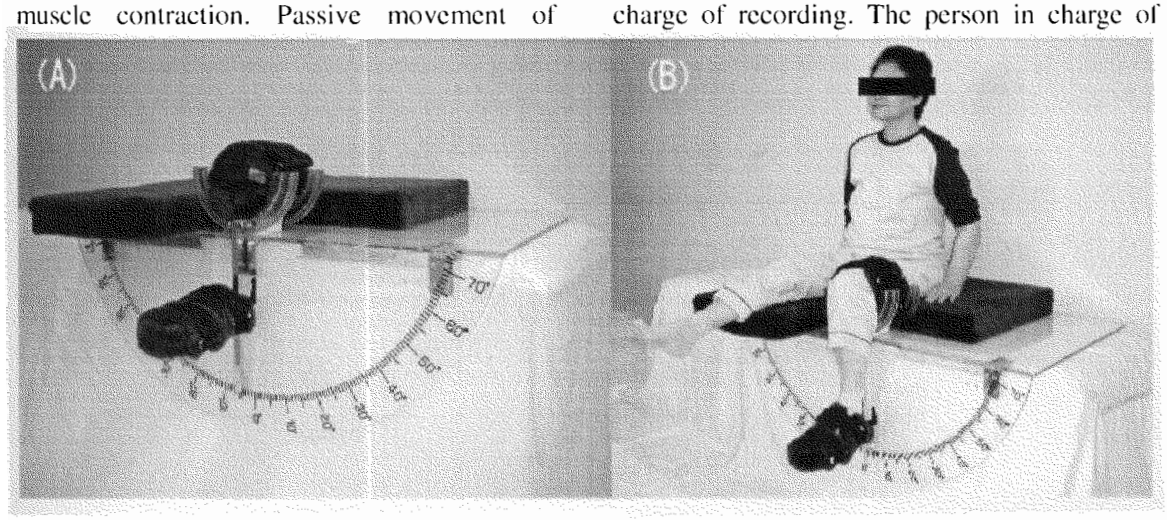

Figure 1. Original goniometer for the present prospective study.

(A) This goniometer had following characteristics. The thigh cuff moving together with the angle indicator was designed to prevent sensory afferents through friction between the table and skin of the thigh that can be generated by rotational movement. In a addition, a protractor with a long diameter (60 cm) was used in order to measure precisely a unit of one degree.

(B) The view of the joint angle measurement. Subjects sat on this goniometer with 0° in the abduction-adduction plane. Knee joint of opposite side was extended and put on the leg board.

passive movement was adequately trained for performance of smooth movement in response to sound signals from an audio-set. With this system, the trained person can carry the vertical arm with a constant angular speed (2°/sec) holding part of the foot trap. The thigh and calf cuff were set for each subject at the chair sitting position. Then, the subject was ordered to close their eyes and the pelvis line was adjusted to be horizontal. Until the measurement starts, the subject was asked to relax for three minutes in order to reduce muscle strain throughout the whole body.

The passive rotation movement was performed externally from an internally rotated position of 20° at the speed of 2°/sec, and the angle detected to be the neutral position of the hip rotation by the subject was recorded. The measurements were performed three times for each subject and the average was recorded. The same testing was performed internally from the externally rotated position of 20° at the speed of 2°/sec. With regard to the expression of measured values, the starting position was designated to be 0°. Accordingly, the true neutral position of hip rotation should be expressed as 20°.

Time-related changes of the detected angle were analyzed whether joint position sense on rotational movement was deteriorated, and how late the impairment remains if it existed. Patient profile such as age, and degree of leg

Table 1. Patient details in the retrospective study

		causative leg position	Interval between THA and initial dislocation (days)
early occurrence group	1	Ext + ER	0
	2	***Unknown***	0
	3	***Unknown***	5
	4	Flex + IR	6
	5	***Unknown***	7
	6	***Unknown***	10
	7	Flex + IR	14
	8	***Unknown***	14
	9	Flex + IR	16
	10	***Unknown***	16
late occurrence group	1	Hyper Flex	380
	2	Flex + IR	412
	3	Hyper Ext	669
	4	ADD + IR	882
	5	ADD + IR	889
	6	Hyper Flex	1188
	7	Hyper Flex	1429

Table 2 . Shift rate(%) of detected angle

	from internally rotated position				from externally rotated position			
	1w	2w	3w	4w	1w	2w	3w	4w
internally direction	94.4	97.2	90.7	85.2	65.7	66.7	55.6	53.7
no shift	0.9	0.9	4.6	1.9	5.6	1.9	9.3	5.6
externally direction	4.6	1.9	4.6	13.0	28.6	29.6	34.3	38.9

(%)

lengthening were also examined for the relation with joint position sense.

The data obtained from measurements during 4 weeks, and patient profile was analyzed using One-factor ANOVA. The Tukey-Kramer method was used for the post hoc test. All statistical analyses were performed using SPSS (version11.0 J; SPSS Japan Inc., Tokyo, Japan) software.

Results

1) The prevalence of dislocation after THA

Seventeen (2.0%) of 847 patients were identified who had at least one postoperative dislocation of the hip. Recurrent dislocation was observed in 12 (65%) of 17 dislocated

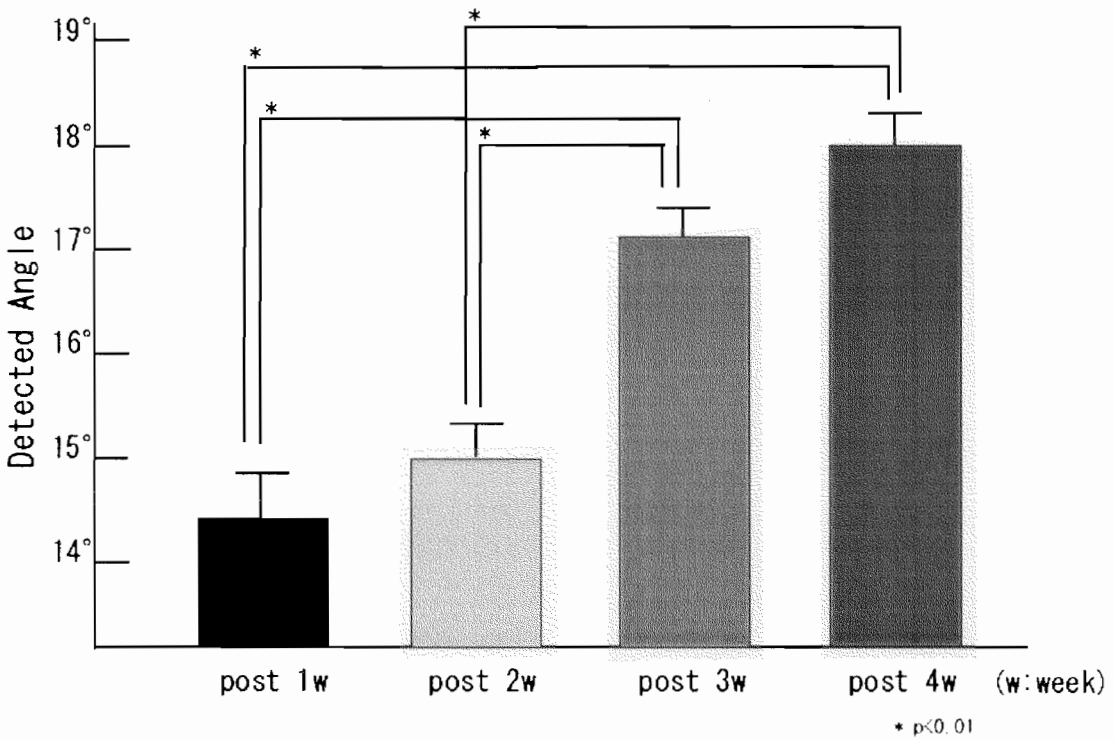

Figure 2. Time related changes of postoperarive proprioception starting from internally rotated position. Values are presented by means ± SD. *: p<0.01

patients. The postoperative dislocation was classified as early (<12 months) or late (>12 months) depending on the interval after surgery [5]. Ten cases were categorized as an early dislocation and 7 cases as late. Six (60%) of 10 early dislocation cases could not explain how they had dislocation, while all (100%) 7 late dislocation cases were clearly aware of the leg position leading to dislocation (Table 1).

2) The time-related change of joint position sense after THA

The rate (%) of shift of the detected angle is shown in Table 2. In more than 90% of all patients, the rotationally neutral position when it was measured from internally rotated position shifted toward internal rotation at 1 to 3 weeks after surgery. In more than 65% of all patients, the rotationally neutral position when it was measured from the externally rotated position also shifted toward internal rotation at 1 to 2 weeks after surgery although the shift rate was less than that from the internally rotated position. The detected angles (mean ± SD) of the rotationally neutral position at each postoperative week from the internally rotated position and from the externally rotated position are presented in Figures 2, 3 and 4, respectively. The detected angles were 14.3° ± 3.4° from the internally rotated position, and 22.1° ± 4.1° from the externally rotated position 1 week postoperatively. The detected angles were 18.0° ± 2.1° from the internally rotated position, and 20.4° ± 3.0° from the externally rotated position 4 weeks

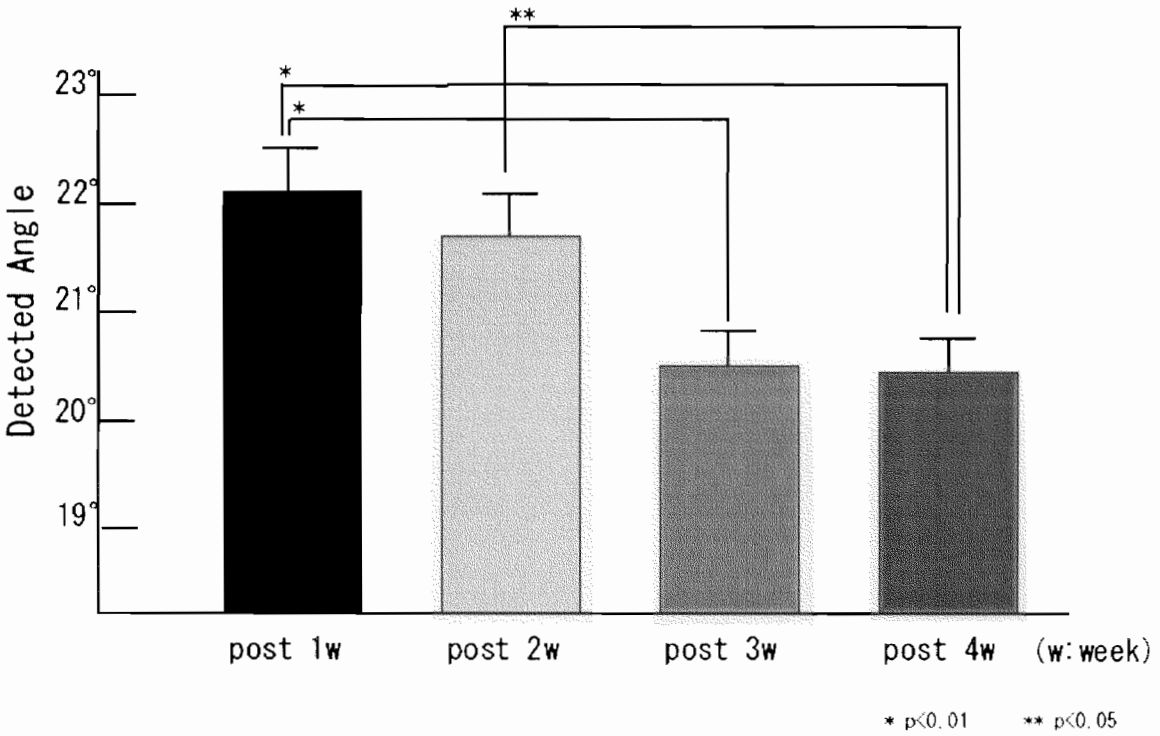

Figure 3. Time related changes of postoperarive proprioception starting from the externally rotated position. Values are presented by means ± SD. *: p<0.01, **: p<0.05

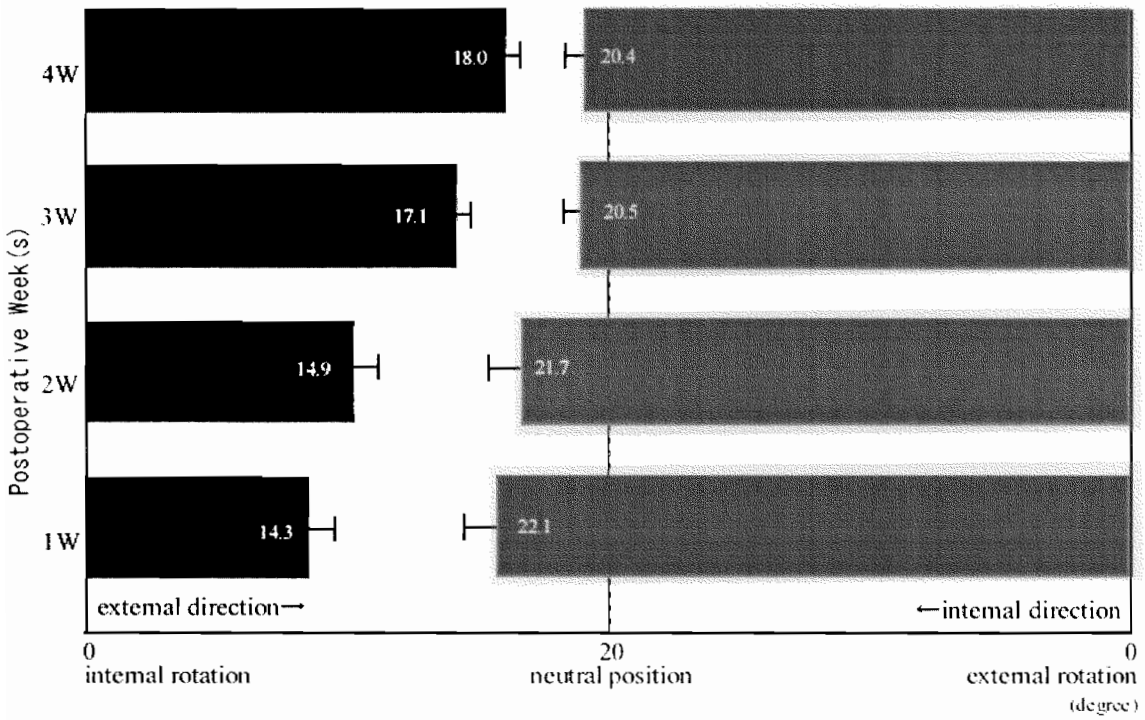

Figure 4. Summary of time related change of the detected angle.

postoperatively. The detected angles from either the internally rotated position or externally rotated angle tended to reach 20° (neutral) during the course of the study. The significant differences of the detected angle from the internally rotated position were found between 1 and 3, 1 and 4, 2 and 3, and 2 and 4 weeks postoperatively. The significant differences of the detected angle from the externally rotated position were found between 1 and 3, 1 and 4, and 2 and 4 weeks postoperatively with lower p values. The joint position sense on rotation was shown to be restored gradually after surgery.

Repeated measures analysis of variance (ANOVA) was used to test the relation between either age or degree of leg lengthening, and joint position sense. These variables were not found to have a significant relation with joint position sense.

Discussion

Postoperative dislocation of THA is one of the most disabling complications requiring emergency care. Many causative factors were suggested to be associated with dislocation. However, a lack of proprioception as a causative factor for this complication especially during the immediate postoperative period has rarely been reported [5]. Little information is available regarding proprioception of the hip joint following THA [6-9]. Based on previous cadaver dissections [10], there is little doubt that the sensory innovation to the hip joint is disrupted during the surgical approach although

the form and extent of re-innervation following THA is not clarified. In the present retrospective study, 60% of the patients with immediate dislocation could not explain their leg position, while all patients with late dislocation were clearly aware of their leg position. In view of this, there could exist a lack of proprioception immediately after surgery that could be transient and possibly be restored during the postoperative course. Passive hip joint position sense could be relatively spared through preservation of extra-articular mechanisms following this surgical denervation. However, only cross-sectional studies on small number of the patients have been performed regarding flexion and the abduction plane of the hip joint [6, 7].

The present prospective study represents an attempt to provide a new assessment for hip joint position sense. Firstly, we focused on the early postoperative period and selected the passive rotation movement that causes much more strain of the hip joint capsule than other directions such as flexion-extension and abduction-adduction. Other reasons why movement of rotation was selected are as follows: (1) Axis of rotation easily increases tension to the joint capsule. (2) The fixation of the pelvis and the compensatory motion are easily obtained in the chair sitting position. (3) The position of 0° rotation (neutral position) can be easily set in the chair sitting position. (4) The movement of excessive rotation is one of the major risk factors for postoperative dislocation.

The results from the present time course study on 108 patients suggested that hip joint position sense of rotation after THA was deteriorated at 1 to 2 weeks but restored largely at 3 to 4 weeks postoperatively. Coincidentally, Zati et al. [9] reported a transient decrease of hip joint position sense. They gave an assignment of drawing a curved and a straight line using an operated limb to subjects who had THA and examined its accuracy. As a result, a significant decrease of the accuracy was found one week after surgery, but significant recovery was also observed 40 days postoperatively. The present retrospective study also revealed that all of the early dislocation occurred within 16 days, which is consistent with the previous findings that most frequently a hip dislocates during the immediate (<2 weeks) postoperative period [5]. Furthermore, rotational proprioception of the hip joint shifted internally the rotated position during 1 to 2 weeks postoperatively, which could easily lead to posterior dislocation in combination with hyperflexion and adduction of the hip joint. In view of these findings, intensive care to prevent dislocation is recommended especially during the first 1 to 2 weeks.

Miki et al. reported that the formation of pseudocapsule after THA was immature at 8-10 weeks postoperatively based on arthrographic and operative findings [11]. Accordingly, it could be too early for joint receptor sites to have regrown within 4 to 6 weeks postoperatively in either the present study or the study by Zati et al. Joint position sense could be restored through preservation of extra-articular mechanisms.

Nevertheless, joint receptors may provide some information on joint position [8, 12, 13]. Rossi et al. reported that capsule receptors in the hip can be considered as rotational limit detectors [12]. This theory could be supported by the present findings that hip joint position sense was temporarily deteriorated in terms of rotation after THA through entire capsulectomy. In a addition, increasing numbers of studies have reported that the dislocation rate after THA decreased to a large extent by posterior soft tissue repair including that of the joint capsule [3, 14, 15]. Although a decreased rate of dislocation was suggested to result from mechanical reinforcement to prevent excessive flexion and to result from acceleration of pseudocapsule formation, capsular repair might have an additional effect of early restoration of deteriorated joint position sense. Further investigations on the joint position sense for patients who received posterior capsulorrhaphy are clearly needed.

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