Therapy of spondylosisthesis by repositioning and fixation of the olisthetic vertebra

Therapy of Spondylolisthesis by Repositioning and Fixation of the Olisthetic Vertebra

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An operation for spondylolisthesis should be resorted to when conservative therapy fails. The following goals were considered in developing the operative technique described here[5–7]: (1) to normalize the mechanical load on the spine and to replace the olisthetic vertebra to its original position; (2) to develop a posterior approach to the lumbar spine so inspection of the nerves of the cauda equina is possible; (3) to develop a technique whereby the olisthetic vertebra can be pulled back to its original position and fused there.

In the development of this operation the resistance of the intervertebral disk to forward–backward displacement was measured to determine the forces necessary to replace the olisthetic vertebra. An artificial fracture in the interarticular part of the neural arch in a post-mortem specimen was produced. The load-deformation characteristics in forward–backward displacement were measured on an INSTRON testing machine. With the help of this experimental apparatus the intervertebral disk can be loaded in a position of true shear. The data obtained regarding properties of the disk material were fitted into a mathematic model of the olisthetic area so that the necessary repositioning forces could be calculated.[9] The results persuaded us to choose the procedure described below.

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METHODS

Two methods of operative repositioning of the olisthetic vertebra were used depending on whether the degree of slip was less than 30 per cent or more than 30 per cent. Olisthesis greater than 30 per cent was repositioned during operation; while olisthesis less than 30 per cent was repositioned postoperatively. Most of the resistance to repositioning can be removed by sectioning the various ligaments.

OLISTHESIS GREATER THAN 30 PER CENT

For operation the patient is in the kneeling position. For this purpose we use the frame developed by Hastings.[3] By suspending the abdomen, pressure on the vena cava is decreased. The blood vessels within the intervertebral foramina empty directly into the vena cava. As a result of decrease in intravenous pressure made possible by the Hastings frame, blood loss is approximately 75 per cent less than during comparable operations with the patient prone on bolsters. The exact level where the incision is to be made should be predetermined. The arch of L5 is often dysplastic, thus the spinous process of L5 is rudimentary and difficult to recognize. Therefore, mistakes in segment are rather easily made. During operation certain distances should be measured, as noted in Figure 2, and the point of reference for these measurements determined. This point should not be altered as the operation progresses. The spinous processes of L3 and L4 serve as a point of reference.

In case of an L-5-S1 spondylolisthesis the sacrum is exposed by a midline incision from L3 to S2. The arches of L3 and L4 are separated from their musculature, and their comparative sizes, as well as those of L5 and S1 noted. By taking hold of the spinous process of L5 with a forceps and moving it the stability of the loose posterior arch of L5 can be judged.

In an L5 spondylolisthesis the ligamentum flavum between the arches of L4-L5 and L5-S1 is removed. Ordinarily the entire separate pos-

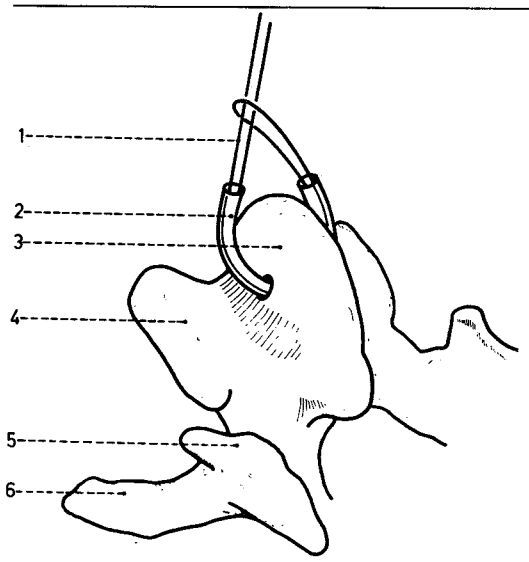


FIG. 1. Attachment of the stainless steel wire to the processus spinosus. (1) Stainless steel wire. (2) Plastic hose. (3) Spinous processes. (4) Inferior articular process. (5) Superior articular process. (6) Transverse process.

terior element of L5 is removed. The cauda equina and nerve roots can then be inspected. The root of S1 can be seen as it passes back over the body of S1; generally it is not very adherent and can be moved about easily. However, depending upon amount of slip, a great deal of tension may be present in the nerves of the cauda as they pass over S1. The L5 nerve root may also be very taut. The following situations may be encountered: (A) the L5 root may still be in its normal position. In this case, fragments of ligamentum flavum that were torn by the olisthesis may have caused some adhesion of the root to surrounding tissues; (B) as the vertebral body displaced ventrally the root may have been pulled along with it. In 2 cases the root had displaced so far that it was found in the intervertebral space. In both cases there was a tough tissue 1 cm in thickness posteriorly. This strong ligament alone would prevent repositioning. Consequently removal of this tissue is necessary.

Incisions are now made over the iliac crests on both right and left. These lateral approaches are needed for the following reasons: (1) only thus may one get reliable information regarding the relationship of the transverse processes to the sacrum; (2) through these incisions one may cut the short ligamentous connections without damaging the transverse processes. These short, strong ligaments are the main obstacle to repositioning. (3) By these incisions the roots also can be loosened from their surroundings, so that they will displace posteriorly as the olisthetic vertebra is repositioned. In cases where there is a high degree of slip the upper part of the body of S_1 may have to be removed. Accurate markings on the roentgenograms should have been made preoperatively showing the amount and the angle of bone removal from the upper border of S1. Experience has taught us that we are likely to err on the conservative side and remove too little bone and as a result there is marked resistance to moving the body of L5 back to its normal position. The angle and

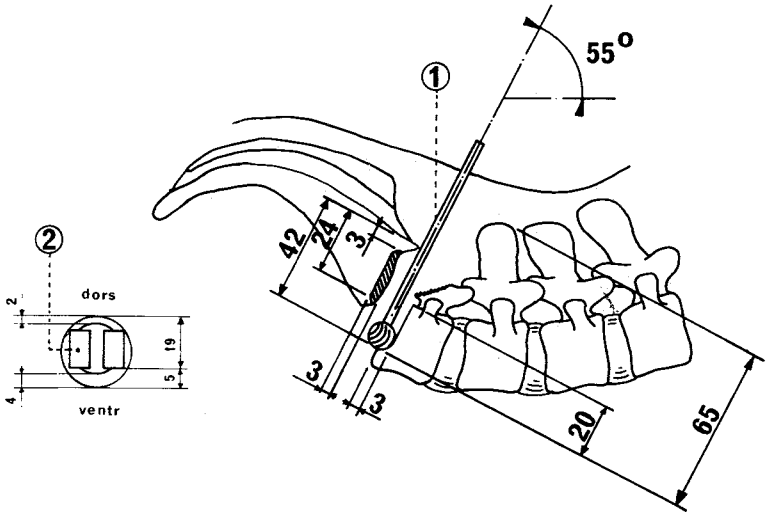


FIG. 2. Working plan for interbody fusion.

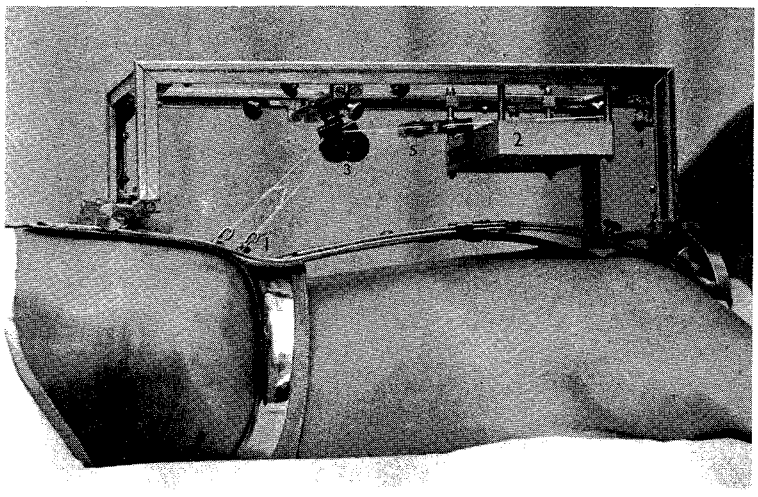


FIG. 3. Traction apparatus used for repositioning in spondylolisthesis. (1) Steel wires. (2) Motor spring. (3) Wire guiding rolls. (4) Winding mechanism. (5) Double pulley.

degree of bone removal must have been carefully planned ahead of time. Even a small degree of residual resistance will make complete apposition of boney surfaces impossible. After having removed the necessary amount of bone the disk space is curreted to get rid of all remaining disk material. Considerable time is required to do this, particularly in the case of high grade slip where there is a lot of disk tissue lying out in front of the body of S1.

After removing as much of the resistance to repositioning as possible both medially and laterally, traction is applied by means of the wire through the spinous processes of L3 and L4. In placement of these wires holes 3-4 mm in diameter are made with a special forceps. A plastic tube is passed through the hole and a doubled stainless steel wire 0.4 mm in diameter is passed through the plastic tube and a loop formed in the wire posterior to the tip of the spinous processes as shown in Figure 1. A plastic hose is used to prevent bone erosion. The sterile wires are passed out through the skin, through a pulley, and attached to a spring-loaded traction apparatus. As much as 15 kg of traction may be necessary. A major danger is root compression during repositioning. The articular processes will have been partially removed, so the shape of the foramen has been altered to prevent nerve compression. By now we have a good idea of the situation that will exist after repositioning.

In order to retain an adequate foramen as little bone as possible should be removed from the distal surface of the body of L5. If necessary, little notches can be chiseled from both L5 and S1 to create new foramina. When repositioning is complete and it is certain that the 2 vertebral body planes, *viz.* the bottomside of L5 and the topside of S1 are in contact, and their cartilaginous layers have been removed, it can be assumed that these surfaces will grow together rapidly. In this case the application of bone grafts for fixation is not needed. The wound is closed. Traction is maintained by steel wires which pass out through the skin to the traction apparatus (Fig. 3). Traction is maintained until the vertebrae have fused.

OLISTHESIS LESS THAN 30 PER CENT

For reduction of slip that is less than 30 per cent we also apply traction in the same way. In these cases it is not necessary to cut the ilio-lumbar ligaments. Only 2 incisions need be made, the mid-line incision and one over one iliac crest for removal of bone graft. An interbody fusion from the posterior route is practically always done for the following reasons: (A) compression of the grafts is thus maximal; (B) displacement of the graft will seldom occur because the grafts themselves produce stability. (C) Both reduction and grafting can be done at one operation.

Two grooves are milled into the surfaces of the respective vertebrae (Fig. 2). The dimensions of the graft are determined by the size of the disk space. The surgeon strives to produce compressive stress on the contiguous bony surfaces to promote bone growth; when this can be accomplished the situation is extremely favorable for solid bony union.

Traction is applied postoperatively with the traction apparatus shown in Figure 3. Both

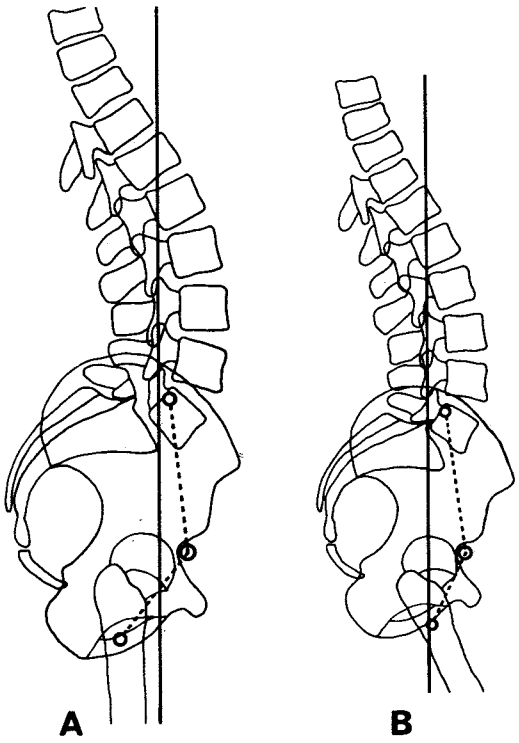


FIG. 4. State of the spine, pelvis and hips, before and after repositioning.

the direction and amount of traction can be changed by adjusting this apparatus. The directions of the forces exerted are of paramount importance; the resultant of the correction forces should run through the center of the olisthetic disk. One can gradually bring both wires to proper tension by simultaneously winding the mechanism. Figure 4 shows tracings of the situation: (A) before operation, and (B) after operation. In both sketches the psoas length is the same.

It can be seen that flexion occurs in the hips during repositioning. As a matter of fact, if the patient is lying with hips extended during the operation,[4] it is impossible to obtain reduction because of tightness of the psoas. After operation the patient must also lie with his hips flexed (Fig. 5).

Our thesis is that if stability in the lumbosacral area is to be expected the olisthetic vertebra should be replaced in its normal position and fused solidly to the sacrum. By this means the extremely complicated system of equilibrium, which has been interrupted by spondylolisthesis, is returned to normal. In this connection, we believe that the M. psoas, the M. erector trunci, and the M. quadratus lumboraum play important roles. At our institution the influence of each of these muscles is being examined further.

Since June, 1971, 19 cases have been operated upon according to the method described. There were 11 women and girls and 8 men and boys. In general, surgery was performed when a long period of conservative therapy failed. In some cases the existence of radicular pain, or slight paralysis made an operation necessary. In the younger age group progression of olisthesis also made surgery necessary in a few cases.

No final evaluation can be made concerning success in some of our more recent cases. However, considering our previous experience we believe we can assume that the results will not change radically. Several patients who still had pain at the time of leaving the hospital have gradually recovered. Table 2 gives a summary of the patients' preoperative complaints and those at the time of a recent check-up. The date of operation and the patient's age at time of operation are also recorded. Check-up examinations were made 3 months to 4 years postoperatively. It may be concluded

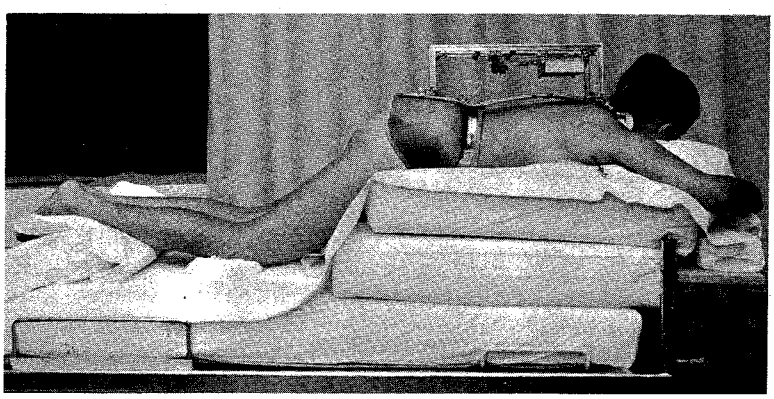


FIG. 5. Patient's nursing-posture with flexed hips.

TABLE 1.

No., Sex	*Age: yrs, mon.*	*Amount of slip according to Meyerding's division.*	*Amount of reduction*
1, F	13, 6	I	correction <50%
2, M	15, 7	II	correction >50%
3, F	10, 6	I	full correction
4, M	18, 2	I	full correction
5, M	26, 9	I	full correction
6, M	10, 7	II	correction >50%
7, F	16, 2	I	full correction
8, F	20, 1	I	full correction
9, M	10, 8	II	correction <50%
10, F	8, 2	IV	full correction
11, F	52, 1	II	full correction
12, F	10, 3	II	full correction
13, F	28, 4	II	full correction
14, F	16, 8	I	increase of olisthesis
15, F	20, 4	III	full correction
16, M	22, 3	I	full correction
17, F	37, 6	I	correction <50%
18, M	38, 3	I	correction <50%
19, M	16, 4	III	full correction

from Table 2 that in 13 out of the 19 cases the surgery was considered successful. Five patients still had slight complaints but considerably less than before the operation and were still improving. Clearly, one patient had more trouble than before operation; this was the eldest patient in the group. The results at last follow-up examination can be summarized as follows: free from complaints–13 (70%); slight, and still decreasing complaints–5 (25%); increasing complaints–1 (5%). In 12 cases (65%) entire repositioning was obtained (Table 1). In this connection it should be noted that all cases of severe olisthesis, that is those having Meyerding's third or fourth degree were reduced completely.

CASE REPORTS

The following are case reports of 2 patients treated by the technique described.

Case 1. Female, born March 5, 1964. *History:* Mother had noted that the child had a peculiar gait and seemed to have increasing lordosis. *Physical examination:* When either standing or walking it was obvious that severe deformity of the lumbar spine existed. *X-ray examination:* There was severe spondylolisthesis amounting to 75 per cent. The hip joints were shifted far forward and thus in front of the load line. In the oblique X-ray distinct lysis of the pars could be seen. *Operation:* Surgery was carried out on August 18, 1972. Three incisions were made. It became evident that resistance was principally on the lateral side, *viz.* at the site of the sacro-transverse ligaments which were cut. In order to obtain good reduction approximately 2 cm of the topside of S1 had to be removed. By doing so the angle with the base of the sacrum was considerably altered. After complete repositioning traction was

TABLE 2. Pre and Postop Status

No, Sex	Age: yrs, mon.	Date of Operation	Reason for Operation	Postop Status	Method of Arthrodesis
1, F	13, 6	7-6-71	M. Scheuermann and progressive postural deterioration	Free from complaints; postural improvement especially concerning lordosis	Intertransverse process grafts
2, M	15, 7	2-8-71	Backache, left, and pain in sacroiliacal joint, right	Distinctly less complaints; takes part in competitive sport (cycle-racing)	Intertransverse process grafts
3, F	10, 6	25-1-72	Progressive postural deterioration	Decrease of lordosis, free from complaints	Two intercorporal grafts
4, M	18, 2	16-3-72	Chronic backache. Radicular pain, more on the right side than on the left	Free from complaints	Two intercorporal grafts
5, M	26, 9	27-3-72	Backache. Radicular pain. Right	Free from complaints; takes part in competitive sport (volley)	Two intercorporal grafts
6, M	10, 7	9-5-72	Sharp increase of lordosis; progression of spondylolisthesis	Lordosis normalized; free from complaints	Two intercorporal grafts
7, F	16, 2	25-5-72	Backache low lumbar, right	Free from complaints	One intercorporal graft, left, in connection with scoliosis
8, F	20, 1	6-6-72	Serious back-complaints and radicular pain, left	For a long time recurrent, decreasing complaints. Free from complaints now	Two intercorporal grafts
9, M	10, 8	28-6-72	Progressive postural deterioration	Postural normalization free from complaints	Two intercorporal grafts
10, F	8, 2	18-8-72	Complaints when moving and playing	Free from complaints	One intercorporal graft, right

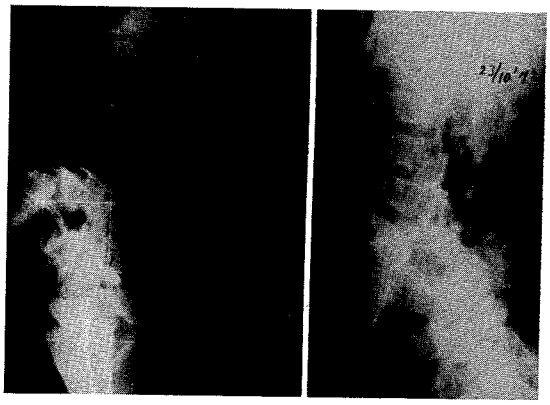
applied on the spinous processes of L_3 and L_4 amounting to 2 x .5 kg (Fig. 6). *Postoperative course:* Traction was removed in 7 days and the child was released in a Böhler cast. Few postoperative problems arose. The reduction was maintained. Drawings made with the help of the pre- and postoperative X-rays show the position of the vertebrae before and after surgery (Fig. 6). The fifth lumbar vertebra which had fourth degree slip has been repositioned completely.

Case 2. Female, born June 23, 1953. *History:* Patient visited the policlinic because of back pain and incontinency of the bladder. She also complained of some numb spots on her leg. She was unable to walk very far. *Physical Examination:* It was found that the patient was a hyper-mobile type. Pressure over the lumbosacral area caused no pain. Her back showed a distinct "step-off"; her right knee was unstable. No neurological abnormalities were found. In general her musculature development was satisfactory. Only slight shortening of the hamstrings was observed. *X-ray Examination:* The AP roentgenogram showed a slight left-convex scoliosis at L4-L5, pelvic tilt

TABLE 2. Pre and Postop Status

No, Sex	*Age: yrs, mon.*	*Date of Operation*	*Reason for Operation*	*Postop Status*	*Method of Arthrodesis*
11, F	52, 1	24-8-72	Chronic back-complaints; radicular pain, left	Increase of complaints; after two explorations, also further deterioration	No grafts; direct fixation of L5 to S1
12, F	10, 3	5-10-72	Soon tired and back-complaints in case of long-lasting exertion	Free from complaints	No grafts; direct fixation of L5 to S1
13, F	28, 4	6-2-73	Chronic back-complaints, radicular pain and sensibility-disturbance of right leg and foot	Not yet entirely free from complaints. Improving more and more	Two intercorporal grafts
14, F	16, 8	12-6-73	Chronic back-complaints, especially in case of static posture (school)	Free from complaints	Two intercorporal grafts
15, F	20, 4	15-11-73	Back-complaints. Paresis and paralysis of both legs. Incontinence as to urine and feces	Decrease of paresis and incontinence; subjectively, uncommonly satisfied	No grafts; direct fixation of L5 to S1
16, M	22, 3	29-5-74	Backache and radicular pain, left. Hypesthetics L4-S1	Short lasting hyperesthetics L5-S1. At first slight residue-complaints during playing games. Free from complaints now	No grafts; direct fixation of L5 to S1
17, F	37,6	8-10-74	Chronic back-complaints; radicular pain, more right than left	Much improvement; frightened of recurrence	No grafts; direct fixation of L5 to S1
18, M	38, 3	27-1-75	Radicular pain, left. Chronic, ever increasing backache	When mobilizing, acute olisthesis after entire repositioning. Growing improvement of preop pattern of complaints	No grafts; direct fixation of L5 to S1
19, M	16, 4	8-4-75	Chronic, backache; reflex change in Achillis tendon, left	Free from complaints	No grafts; direct fixation of L5 to S1

approximately 1 cm. The lateral roentgenograms show spondylolisthesis of approximately 70 per cent with spondyloptosis of L5. The upper side of the sacrum was rounded off. A bony union between the body L5 and the ventral side of S1 may have already existed. *Operation:* On November 15, 1973, an operation was performed. The disk at L5-S1 was completely removed. After having chiseled away the upper side of the sacrum, the distal cartilage plate of L5 was removed. L5 was repositioned. Both abutting faces appeared to contact each other well, so that an intercorporal graft was unnecessary. The traction applied amounted to 2 x 4 kg. *Postoperative course:* Correction was achieved slowly. On December 20, 1973, 35 days postoperation, the traction wires were removed and mobilization begun. Due to the extreme flexion of the thigh this required quite some time. On Janu-



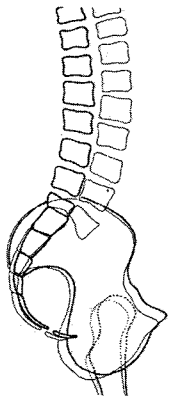


FIG. 6: (left) Pre- and (center) postoperative X-rays. (right) Pre- and postoperative spinal positions.

ary 30, 1974, the patient was discharged from the hospital. At a check-up visit 6 weeks later it appeared that her pelvis was still in flexion when standing. Definite motor disturbances still existed. At the check-up on June 24, 1974, her posture and musculature had improved considerably. Her incontinence was also improving.

SUMMARY

A new method for reduction of the slip and stabilization in spondylolisthesis is presented. A detailed description of the operative technique is given. Of special importance to repositioning of the olisthetic vertebra is sectioning of the ilio-lumbar and ilio-transverse ligaments. It is also most important to remove a portion of the superior surface of S1 in those cases with greater than 30 per cent olisthesis. A distinction in the technique of surgery is drawn between cases with less than 30 per cent of slip and those with greater than 30 per cent. In those with less than 30 per cent 2 bone grafts taken from one iliac crest are placed between the repositioned body of L5 and the body of S1. In those with more than 30 per cent slip grafts are not necessary. In these a portion of the superior surface of S1 is removed in such a way that the body of S1 fits snugly against the under surface of the repositioned body of L5. A special traction apparatus with wires through the spinous processes of L3 and L4 is used to accomplish reduction of the olisthetic vertebra. This apparatus is spring-loaded and is mounted on a modified Milwaukee brace. The patient remains in bed while this is worn. When it is believed that there is enough solidity in the fusion between the bodies of L5 and S1 the traction apparatus is removed and the patient allowed up.

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