FIXED PELVIC OBLIQUITY AFTER POLIOMYELITIS

CLASSIFICATION AND MANAGEMENT

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We classified fixed pelvic obliquity in patients after poliomyelitis into two major types according to the level of the pelvis relative to the short leg. Each type was then divided into four subtypes according to the direction and severity of the scoliosis.

In 46 patients with type-I deformity the pelvis was lower and in nine with type II it was higher on the short-leg side. Subtype-A deformity was a straight spine with a compensatory angulation at the lower lumbar level, mainly at L4-L5, subtype B was a mild scoliosis with the convexity to the short-leg side, subtype C was a mild scoliosis with the convexity opposite the short-leg side, and subtype D was a moderate to severe paralytic scoliosis with the convexity to the short-leg side in type I and to the opposite side in type II.

A combination of surgical procedures improved the obliquity in most patients. These included lumbodorsal fasciotomy, abductor fasciotomy and stabilisation of the hip by triple innominate osteotomy with or without transiliac lengthening. In patients with type ID or type IID appropriate spinal fusion was usually necessary.


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Pelvic obliquity due to neuromuscular imbalance is a major orthopaedic problem. Mayer was the first to suggest that fixed paralytic pelvic obliquity was due to suprapelvic or infrapelvic contractures. Yount and Irwin regarded pelvic obliquity as part of multiple deformities caused by contracture of the iliobibial band in patients with poliomyelitis.

Winter and Pinto thought that it was caused either by unequal leg length, contractures about the hips as part of structural scoliosis, or a combination of these.

We have classified fixed pelvic obliquity after poliomyelitis according to clinical and radiological findings and attempted to develop appropriate guidelines for treatment.

PATIENTS AND METHODS

We reviewed the medical records and radiographs of 55 patients (37 women and 18 men) treated for pelvic obliquity after poliomyelitis at the Seoul National University Hospital from 1985 to 1993. Their mean age at operation was 27 years (15 to 49). The mean duration of follow-up was 5 years 9 months (2 years 6 months to 11 years 5 months).

Radiological classification. Radiographs taken with the patient unsupported, upright (standing or sitting) and supine together with anteroposterior lateral bending and thoraco-lumbar views were reviewed (Figs 1 and 2). Patients with no pelvic obliquity on supine radiographs were excluded as they were judged not to have a fixed deformity. We assessed pelvic obliquity in relation to the hips and legs as well as to the spine.

We classified the obliquity into two major types according to the direction of the pelvic inclination relative to the short leg; each was then divided into four subtypes according to the direction of the spinal curvature relative to the short leg and the severity of scoliosis. The short leg was determined by measuring the spinomalleolar distance and from a scanogram. In type-I deformity the pelvis was lower on the side of the short leg, and in type II it was higher on this side. In subtype-A deformity the spine was straight with localised lower lumbar compensation, mainly at the L4-L5 level. Patients with subtype-B deformity had a mild, long scoliotic curve with the convexity to the short-leg side. In subtype-C deformity there was a mild scoliotic curve with the convexity opposite the short leg, and in subtype D there was severe paralytic scoliosis associated with pelvic obliquity, with the convexity (of the lumbar curve in cases of double curves) to the side of the depressed hemipelvis, namely to the short leg in type I and to the opposite side in type II.

Operative procedures

Lumbodorsal fasciotomy. With the patient prone and the
Fig. 1
Classification of fixed pelvic obliquity (S, short-leg side; V, convergent iliolumbar angle).

Fig. 2
Radiographs of type-I and type-II deformities according to subtypes.
trunk slightly flexed, a slightly curved transverse incision is made immediately above the iliac crest from the posterior axillary line to the spinous process of the fifth lumbar vertebra. The deep subcutaneous fascia is then divided in line with the skin incision. The thick posterior layer of the lumbar fascia is divided transversely from the iliac crest, leaving the underlying erector spinae muscle intact and extending to the spinous process of the fifth lumbar vertebra. The interspinous ligaments between L4 and L5 and L5 and S1 are divided. Laterally, the division includes that portion of the lumbar fascia in which both the posterior and anterior investing layers blend. The erector spinae muscle is reflected medially, and the fascial attachment and short rotator muscles freed from the transverse processes of L4 and L5. Finally, the thick arcuate band of the iliolumbar ligament is palpated and divided. Haemostasis is obtained and gelfoam is placed in the iliolumbar corner and at the lateral corner of the erector spinae muscle. The deep subcutaneous fascia and skin are closed. After operation skeletal traction (4.5 kg) is applied to the ipsilateral limb for three weeks followed by bending exercises.

Abductor fasciotomy. Our technique is identical to that of Eberle’s modification of the original Soutter and Campbell procedures.

Radiological measurements. Pelvic obliquity was determined by measuring the iliolumbar angle (Fig. 3). On supine lateral bending radiographs of the pelvis and lower lumbar spine, a line was drawn connecting the apices of both iliac crests and another line along the bottom of the fourth lumbar vertebra. The iliolumbar angle was measured at the convergence of these two lines. The scoliotic curves in type-ID and type-IID deformities were measured by the Cobb method.

Statistical analysis of changes in the iliolumbar angle. Using the appropriate software (SAS Institute, Cary, North Carolina), we used the paired t-test in type-IB patients (more than 15) and the non-parametric Wilcoxon signed-rank test in type-IA and type-IC patients (less than 15). A p value of less than 0.05 was considered significant. Statistical analysis was not possible for type ID and type II (less than five patients).

RESULTS

Forty-six patients had type-I and nine had type-II deformities. Of the former 22% had bilateral involvement compared with 88% of the latter. Type-II deformities were more complex and were associated with severe clinical manifestations (Table I).

Classification and treatment (Table II)

Type IA. Seven patients had type-IA deformities and soft-tissue release was carried out in five. The contracted lumbar fascia was released in two patients on the side of the converging iliolumbar angle, where the pelvis was elevated opposite the short leg, and in three patients abduction contracture of the hip on the short-leg side was treated by abductor fasciotomy. Triple innominate osteotomy was used to correct unstable hips on the short-leg side in two patients, giving additional transiliac lengthening. The same procedure was carried out in one patient on the side opposite the short leg. The mean iliolumbar angle decreased from $9.4^\circ \pm 3.5^\circ$ before surgery to $4.0^\circ \pm 2.1^\circ$ at the final assessment.

Type IB. This was the largest group with 24 patients (44%).

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Table I. Classification of 55 patients with fixed pelvic obliquity after poliomyelitis. Numbers in parentheses indicate the number of patients with bilateral involvement of the lower limb.
They had mild scoliosis with a mean Cobb angle of 17.3° convex to the short-leg side. Lumbodorsal fasciotomy was performed in eight patients on the side opposite to the short leg, where the iliolumbar angle converged. Eleven patients had abductor fasciotomy on the short-leg side (Fig. 4). Triple innominate osteotomy was undertaken for an unstable hip on the short-leg side in 16 patients. The mean iliolumbar angle was reduced from 7.6° ± 3.8° before surgery to 5.3° ± 3.3° at the final assessment.

**Type IC.** Eleven patients had mild scoliosis with a mean Cobb angle of 15.3° convex away from the short-leg side. The intervening space between the elevated hemipelvis and the convexity of the spinal curve was narrow. Three patients had a lumbodorsal fasciotomy on the side opposite to the short leg, where the iliolumbar angle converged. Eleven patients had abductor fasciotomy on the short-leg side. Triple innominate osteotomy was undertaken for an unstable hip on the short-leg side in 16 patients. The mean iliolumbar angle was reduced from 7.6° ± 3.8° before surgery to 5.3° ± 3.3° at the final assessment.

**Type ID.** Four patients had a moderate to severe scoliosis with a Cobb angle greater than 40°. Two had spinal fusion with Luque instrumentation incorporating the pelvis for severe uncompensated paralytic scoliosis and pelvic obliquity. An extended lumbodorsal fasciotomy was carried out at the same time with release of the contracted quadratus lumborum and erector spinae muscles from the elevated hemipelvis on the concave side of the curve. Triple innominate osteotomy was performed in all four patients, in three on the short-leg side with transiliac lengthening and in one on the opposite side. Abductor fasciotomy was unnecessary as the deformities of the hip and spine were severe – the hips were flail in most cases. At the final assessment the mean Cobb angle was corrected from 54° to 36° and the mean iliolumbar angle reduced from 8° to 5.3°.

**Type IIA.** Two patients had type-IIA deformities. In both the lumbodorsal fascia on the short-leg side where the iliolumbar angle converged was released. In one patient an abduction contracture of the opposite hip that accentuated the pelvic obliquity was released. In both an elevated, convex pubic rami were preserved.

### Table II. Details of treatment in 55 patients with pelvic obliquity

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<tr>
<th>Type</th>
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<th>Adductor tenotomy</th>
<th>Triple innominate osteotomy</th>
<th>Abductor fasciotomy</th>
<th>Lumbodorsal fasciotomy</th>
<th>Adductor tenotomy</th>
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<td>-</td>
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* combined abductor fasciotomy on the short-leg side and contralateral lumbodorsal fasciotomy in type-I deformities, and combined lumbodorsal fasciotomy on the short-leg side and contralateral abductor fasciotomy in type-II deformities

† combined triple innominate osteotomy on the short-leg side and ipsilateral lumbodorsal fasciotomy in type-II deformities

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**Figure 4a – Radiograph of a 21-year-old man with type-IB deformity. Figure 4b – At the five-year follow-up, the pelvic obliquity has been corrected by abductor fasciotomy on the short-leg side and lumbodorsal fasciotomy on the opposite side.**
adducted and unstable hip on the short-leg side was treated by triple innominate osteotomy with transiliac lengthening. The change in the iliolumbar angle after operation was small; 0° in one patient and 2° in the other.

Type IIB. Two patients had type-IIB deformities. The space between the elevated hemipelvis and the spine was narrow, and the iliolumbar angle converged, resembling a type-IC deformity. Both patients had a lumbodorsal fasciotomy above the elevated hemipelvis on the short-leg side and one also had abductor fasciotomy on the opposite side. In both cases an elevated and unstable hip on the short-leg side was treated by triple innominate osteotomy with transiliac lengthening. There were minor improvements in the iliolumbar angle of 1° in one patient and of 3° in the other.

Type IIC. Two patients had type-IIC deformities. In both lumbodorsal fasciotomy was carried out on the side of the elevated hemipelvis with a short leg (Fig. 5). One patient had an abductor fasciotomy on the opposite side. Both had an elevated and unstable hip on the short-leg side, which was stabilised by triple innominate osteotomy with transiliac lengthening. In one patient there was no change in the iliolumbar angle, but in the other the angle was reduced from 16° to 5°.

Type IID. All three patients in this group had very severe deformities of the pelvis and spine with a mean Cobb angle of 77° and all were treated by spinal fusion using the Luque-Galveston technique in two patients and Cotrel-Dubousset instrumentation in one. An extended lumbodorsal fasciotomy was also carried out in two patients with release of the quadratus lumborum and erector spinae muscles. The mean Cobb angle reduced to 35° after operation. Abductor fasciotomy was performed in three hips in two patients. In one patient an abduction contracture was present opposite the short-leg side accentuating pelvic obliquity, and in the other the contracture was on both sides. All patients had an elevated, adducted and unstable hip on the short-leg side, and were treated by triple innominate osteotomy with transiliac lengthening. The mean iliolumbar angle was reduced from 7.0° to 3.7°.

**Statistical analysis.** The iliolumbar angle was significantly decreased in patients with type-IB, type-IA and type-IC deformities (p = 0.0001 (paired t-test), p = 0.0469 and p = 0.0117 (Wilcoxon signed-rank test), respectively). The small number of patients in each of the other groups precluded statistical analysis. An overall comparison between the iliolumbar angles before surgery and at the last assessment in all patients using the paired t-test showed a significant improvement (p = 0.0001).

Deformities of the hip. In 22% of patients with type-I deformities, the opposite, longer legs were also affected by paralysis, although to a less degree. In those with type-II deformities, most (88%) were affected bilaterally. In type-I patients an abduction contracture requiring release was present in 20 and instability needing pelvic osteotomy in 26. In type-II patients none of the adducted short legs had fixed adduction contracture and all required pelvic osteotomy. In these patients the hips were almost invariably lax, hypermobile and unstable to a varying degree, leading to dislocation. On the opposite side in type-I deformities, in which the hips were adducted, adductor tenotomy was rarely necessary (2 of 46 patients), whereas the abducted hips required abductor fasciotomy in five of the nine patients with type-II deformities.

**DISCUSSION**

There have been no epidemics of acute poliomyelitis in Korea since the early 1970s and the last people to be infected are now in their late thirties.

Functional impairment of sitting, standing and walking is further complicated by...
asymmetrical paralysis and deformities of the legs, which are of unequal length. The ultimate goal of treatment is to achieve a balanced posture in a bipedal stance with minimal support.

In managing these patients we aim first to correct the deformities of the legs. Paralysis of the joints is managed by stabilisation and/or motor balancing and reconstruction. Pelvic obliquity, both above and below the pelvis and including the hips, may be corrected at or around the same time. Attention may then be directed to any minor residual scoliosis, but no surgical correction is usually necessary. Finally, the length of the legs is reassessed and corrected. The emphasis is on the correction of functional and subjective differences in the standing position rather than on true length discrepancies. In patients with collapsing or uncompensated moderate to severe paralytic scoliosis, correction of the scoliosis and pelvic obliquity is undertaken first.

Recent emphasis has been either on paralytic hip instability or on paralytic pelvic obliquity. We have developed a systematic and comprehensive classification of this deformity and have applied it clinically for a number of years.

We classified fixed paralytic pelvic obliquity on the basis of clinical and radiological findings of scoliotic spinal curvature above the oblique pelvis as well as deformities of the hip and of leg length below the iliac crest. A stable and balanced erect posture up to the iliac crest is more important than the degree of pelvic obliquity itself, just as the stable, balanced spine sitting on a level pelvis is more important than the degree of scoliosis present. Thus, the degree of leg-length inequality which is almost always present in these patients, is of fundamental concern.

We divide pelvic obliquity into two major types, depending on the side of the shorter leg. In type I, the pelvis is lower on the side of the short leg and in type II it is raised on this side. Yount, Irwin, and Mayer described the classical deformities of fixed paralytic pelvic obliquity: the hip of the affected limb is abducted, the opposite hip is adducted, the pelvis is elevated on the opposite side, and the convexity of the scoliotic curve is directed towards the affected side. In practice, this is an oversimplification and we have seen many deformities that do not fit this description.

We have found that subtypes A, B and C in our classification system are primarily caused by infrapelvic contractures and those in subtype D by suprapubic contractures. Some may be caused by combined factors and some have bilateral involvement. Iliopsoas contracture, hypoplasia of the hemipelvis and hip dysplasia may also be present. In most patients in our study there was a relatively minor degree of pelvic obliquity, scoliosis was mild and appeared to be stable and non-progressive, and spinal fusion was not considered. For the sake of completeness, we also included subtype D which requires spinal fusion and instrumentation incorporating the pelvis.

In type-I deformities, pelvic obliquity and an abducted hip favoured the short leg and treatment was less aggressive. The opposite limb was normal in most patients (78%) or, if paralysed, usually to a less degree. Typically, the patient was able to walk on both feet, sometimes with an orthosis on the short leg. Occasionally, the deformities compensated for the shorter leg, particularly if there was a mild instability of the hip on the short-leg side. When, however, there was a marked abduction contracture which affected standing balance and the scoliotic curve was accentuated, as in subtype B, or if the instability of the opposite, adducted hip was aggravated, abductor fasciotomy was performed. This was necessary in 20 of the 46 patients with type-I deformities. Combined contralateral lumbodorsal fasciotomy was undertaken in many patients to facilitate maximum correction of the obliquity. Contrary to the classical concept, we rarely found an abduction contracture of the opposite hip that required tenotomy. When the pelvis was levelled, instability of the hip may have been aggravated. In 26 patients with type-I deformities triple innominate osteotomy was carried out with transiliac lengthening and abductor fasciotomy or abductor reconstruction procedures as indicated. Likewise, leg shortening was aggravated functionally, but in many cases transiliac lengthening compensated for this. Any residual shortening was then subjected to limb lengthening.

Type-II deformities were less common and the clinical presentation was quite different. Typically, the short leg was extensively paralysed and shortening was more marked. The opposite leg was also involved in most cases (88%). The elevated hemipelvis and marked instability of the hip accentuated the functional limb shortening and treatment was more aggressive. Frequently, the flail limb dangled as the patient stood on the opposite leg with crutches. Contralateral abductor fasciotomy was performed whenever abduction contracture was present, but in most cases improvement of the unstable hip was not sufficient to withstand weight-bearing. These hips were often dysplastic. Fixed deformities of the pelvic obliquity above the iliac crest remained uncorrected. On the short-leg side, triple innominate osteotomy with transiliac lengthening was always undertaken and combined with ipsilateral lumbodorsal fasciotomy to maximise correction of the pelvic obliquity, stabilisation of the hip and limb lengthening. The degree of iliolumbar contracture was most severe in type-IIB deformity. None of our patients had an adduction contracture on the short-leg side. The hip was invariably unstable and was hypermobile with attenuated adductors. Subluxation or dislocation was often accompanied by iliopsoas contracture. We graded the degree of instability of these paralytic hips and noted that they were lax enough to allow transiliac lengthening. After correction of pelvic obliquity and stabilisation of the hip, abductor-extensor reconstruction was carried out whenever motors were available in order to augment the functional stability of the hip. Leg length was then equalised.

Lumbodorsal fasciotomy is indicated in some patients.
with type-I deformities and in all with type-II deformities (subtypes A, B and C) in which there is a fixed pelvic obliquity with a proven iliolumbar contracture, usually on the side of the elevated hemipelvis. A convergent iliolumbar angle demonstrable on bending studies is useful for determining which side undergoes surgery. In type-II deformities with the short-leg side up, particularly when the elevated and adducted hip is unstable, ipsilateral lumbodorsal fasciotomy is strongly indicated. Sometimes, in type-I deformities, poor posture and function render lumbodorsal fasciotomy desirable on the long, adducted side, even although this means aggravation of effective or functional leg-length discrepancy. Equalisation of leg length is then considered. Patients may complain of backache after walking, and some may have hip pain in the long, adducted limb. These are additional indications.

The degree of correction obtained, in terms of pelvic obliquity, the scoliotic curve and leg-length discrepancy, was small in numerical terms and seldom complete, but clinical improvement was significant. The procedure is relatively simple and safe. In a few patients in subtype D in whom the objective of treatment was correction of scoliosis, we attempted an extended lumbodorsal fasciotomy as an additional procedure at the time of spinal fusion and instrumentation incorporating the pelvis. Quadratus lumborum and erector spinae muscles were divided on the side of the elevated hemipelvis where the concavity of a long C curve or the convexity of the upper curve of a double curve was directed. The iliolumbar ligament was not divided.

We have presented a systematic and comprehensive classification of fixed paralytic pelvic obliquity in relation to the spinal deformity above the pelvis and to the hip deformity and leg-length below it. Certain types of composite deformity are identified to facilitate surgical decision and combinations of operative procedures are suggested. Our classification is a useful guide in the management of this complex and often confusing disorder.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES