

A Study of Scoliosis

— Part II. The Milwaukee Brace Treatment —

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=국문초록=

脊椎側方彎曲에 對한 考察

— 제 2 부 : Milwaukee Brace 를 사용한 보존적 치료 —

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저자들은 서울대학교 의과대학 정형외과학교실에서 1968년 2월부터 1976년 1월까지 만 8년동안 본원에 내원하여 척추측방만곡증을 진단받은 환자 126예중 35예(45만곡)에 대하여 Milwaukee Brace 를 사용한 보존적 치료를 시행하여 만족스러운 결과를 얻었기에 이에 보고하는 바이다.

1. 척추측방만곡증 환자 35예(45만곡)에 대하여 Milwaukee Brace 를 착용시켜 보존적 교정치료를 실시하여 8개월에서부터 60개월까지 평균 30개월간 추후조사를 시행하였다.

2. Milwaukee Brace 를 착용시켰던 환자의 연령은 4.5세에서 16.3세로 평균 12.4세였다. 치료를 시작하기 전의 평균 만곡각은 40.5°였으며, 수동측방굴곡(side bending)에 의한 신연도(flexibility)는 평균 24.3°(60.0%)였다.

3. 평균 최종 교정각은 5.7°(14.4%)로서 대부분의 교정은 Milwaukee Brace 착용 후 일년 이내에 이루어졌으며, 최종 교정각의 65%는 Milwaukee Brace 착용 후 삼개월 이내에 이루어졌다.

4. 만곡형별로는 흉 및 흉요추형 만곡에서 가장 교정이 잘 됐으며, 요추형 만곡에서는 효과가 거의 없었다. 원인별로는 원발성 만곡에서 교정이 잘 됐으나 선천성 만곡 및 신경섬유종증 만곡에서는 좋은 결과를 얻지 못하였다. 만곡의 정도가 심하지 않고 만곡의 범위가 긴 경우에 비교적 교정이 잘 됐으며 결과도 좋았다.

5. 만곡의 정도가 심하지 않고 골성숙이 완료되기 전의 경우에서 Milwaukee Brace 착용은 효과적이었다. 변형이 심한 8예의 만곡증에서는 Milwaukee Brace 를 착용시켜 만곡의 진행을 효과적으로 방지하여 수술에 적합한 연령에 이르도록 할 수 있었다. 골반경사를 동반한 마비형 만곡증에 있어서도 연부조직 신연술을 시행한 후에 Milwaukee Brace 를 착용시켜 척추 후방융합술에 적합한 연령에 이르도록 만곡의 교정내지 그 진행을 효과적으로 방지할 수 있었다.

Many various efforts have been attempted to reduce deformities of the spine over centuries since Hippocrates. Among these contributions, a landmark of progress in the control and

correction of scoliosis in the growing child was development of the Milwaukee brace, which was originally designed by Blount and Schmidt in 1944 as a corrective device in the

operative treatment of scoliosis.

Since that time, the brace has been numerously redesigned to give greater efficiency and comfort, and therefore its use has been extended over. The Milwaukee brace is now devised as not only an acceptable and effective method of non-operative treatment of scoliosis but also a means of providing a removable distraction apparatus to take the place of the distraction jacket, previously used in the operative treatment.

Generally in curves of all etiologies, the brace is much effective to correct or prevent the deformity of the spine in a patient with growth potential, prior to skeletal maturation, and a mild or moderate lateral curvature. Selection of patients, cooperation of patients and their families, a properly constructed brace, and an experienced orthopedic surgeon are all essential for good results.

The study reported here is a statistical evaluation of the results of treatment by Milwaukee brace apparatus in patients follow up for a minimum of eight months with an average follow up of two and a half years.

Materials

Of one hundred and twenty six patients

with scoliosis seen at Seoul National University during the period February 1968 to January 1976, thirty-five patients had been treated by means of the Milwaukee brace at least eight months or more at the time of this analysis of the curve response to the apparatus.

There were eleven males and twenty-four females. The average age of these patients at the time of application was 12.4 years ranging from 4.5 years to 16.3 years. Four patients were under 5; and twenty-seven (77.1%), between 10 to 15; and four, over 15 years old. (Figure 1).

The duration of visit after the time that the deformity of the spine was first noticed was the average 9.8 months ranging from

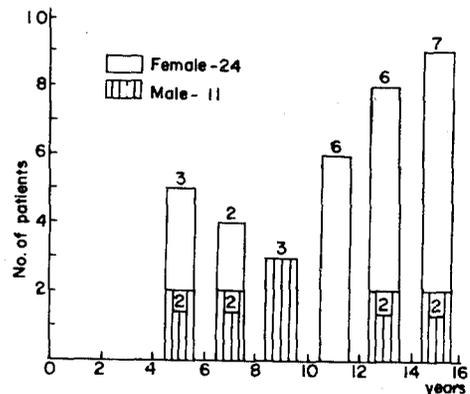


Fig. 1. Age & Sex Distribution at the Time of Treatment.

Table I. Duration Since Scoliosis Observed

Duration*	No. of Patients	Etiology			
		Idiopathic	Congenital	Paralytic	Neurofibromatosis
Less than 3 months	8	6	2	0	0
3 to 6 months	5	5	0	0	0
7 to 12 months	6	5	1	0	0
More than 12 months	16	7	3	5	1
Total	35	23	6	5	1

* Average duration 9.8 months
Range from 3 weeks to 11 years

three weeks to eleven years; less than 6 months in thirteen, between 7 months and 12 months in six, and more than 12 months in sixteen cases. (Table I)

The etiology of the forty-four curves, was idiopathic scoliosis in twenty-three patients with thirty curves, congenital in six patients with seven curves, paralytic in five patients with six curves and neurofibromatosis in one patient. Of the twenty-three patients with idiopathic scoliosis; three were infantile; two, juvenile; and eighteen, adolescent scoliosis. All the paralytic curves were caused by poliomyelitis except one curve by cerebral palsy. Of seven congenital curves, three were due to hemivertebrae and two were fusion of the ribs. (Table II)

A major curve was defined as one that

produced a cosmetic deformity, had major structural changes, which required correction in order to regain compensation and satisfactory appearance. However, if the combined other curve was also significantly structural and created a separate cosmetic problems, it was also considered a major curve. According to this definition, thirty-five patients with forty-four curves were included in this study; twenty-six patients had a single major curve and the remainder nine patients had double major pattern.

The major curves were divided into four groups according to their locations; 1) high thoracic—extending from the seventh cervical or first thoracic to fourth or fifth thoracic; 2) thoracic—extending from sixth thoracic to eleventh thoracic; 3) thoracolumbar—extending

Table I. Etiology and Curve Pattern Correlated with the Severity of the Curve

Etiology & Curve Pattern	No. of Curves	Severity of Curve in Degrees					
		Less than 20	20~29	30~39	40~49	50~59	More than 60
Idiopathic	30	0	11	6	8	5	0
Thoracic	12	0	3	3	4	2	0
Thoracolumbar	4	0	1	1	1	1	0
Double major	14		7	2	3	2	0
Congenital	7	0	1	4	1	1	0
Thoracic	3	0	0	2	0	1	0
Thoracolumbar	1		0	0	1	0	0
Lumbar	1		1	0	0	0	0
Double major	2		0	2	0	0	0
Paralytic	6	0	0	0	3	2	1
Thoracic	1		0	0	0	1	0
Thoracolumbar	3		0	0	2	1	0
Lumbar	0		0	0	0	0	0
Double major	2		0	0	1	0	0
Neurofibromatosis	1	0	0	0	0	1	0
Thoracolumbar	1	0	0	0	0	1	0
Total	44	0	12	10	12	9	1

from sixth or seventh thoracic to first or second lumbar; 4) lumbar—extending eleventh thoracic to third lumbar; 5) double major—combined thoracic and lumbar. There were sixteen patients in thoracic, nine in thoracolumbar, nine in double major, and one in lumbar. The right scoliosis were eighteen cases among all (69.2%), excluding the double major.

The angular deformities of the curves prior to correction were between 20 to 29 degrees in twelve curves, between 30 to 39 degrees in ten, between 40 to 49 in twelve, between 50 to 59 degrees in nine, and more than 60 degrees in one. The average initial curve was 40.5 degrees ranging from 26 to 67 degrees. The correctability of the curve on side bending averaged 24.3 degrees (60.0%). The number of vertebrae involved in a major curve averaged 6.7 with a range of 3 to 10. Over 75% of all the curves contained within 6 to 9 segments in this series.

Method of Treatment

Indication for Milwaukee brace:

The Milwaukee brace was applied in the patients of nearly all etiologies, under sixty degrees of the initial curve except a case with paralytic scoliosis. But the patients with a high thoracic curve were originally excluded in the brace application. At the initial examination, the curvature of the spine was measured the flexibility on side bending. The flexibility of forty percent was prerequisite for the Milwaukee brace usually. The cooperation of both patient and parents were of considerable importance, and socioeconomic conditions could not be ignored as the important factor.

Preapplication Evaluation:

A careful history and thorough physical examination were taken completely. Photog-

raphy was taken routinely to record the appearance of the spine deformity, prior to the application of the brace.

A complete X-ray evaluation was essential and the entire spine and pelvis were included in film. This included standing A-P and lateral view of the entire curves and, to determine the flexibility of all curves, supine anteroposterior view taken with the patients bending maximally to the right and to the left.

Skeletal maturation was determined on the basis of hand and wrist bone age (Greulich and Pyle), the appearance and capping of the iliac apophyses, physiological signs of maturity, chronological age of the patient, the development of the vertebral ring epiphyses, and growth in height.

Treatment Program:

In principle, the brace was worn until the end of the adolescent growth spurt. At first treatment began with full time brace-wearing except only for less than one hour to care the skin daily. Full-time use had been continued until satisfactory curve, stability, and balance were obtained.

Stabilization of correction was defined as the maintenance of correction after the brace was removed. This was demonstrated that the patients curve showed only 3 to 5 degrees of loss by standing roentgenograms taken out of the brace after a trial of 2~3 hours. After the corrected spine was stable, the patient was allowed to remove the brace for three hours twice or three times a week. The daily period out of the brace was increased gradually. In final stages of treatment, the brace was worn at night only. In or out of the brace, activity and exercise were encouraged.

Evaluation Times:

The finding at specific evaluation times

were utilized in analyzing curve response. Standing AP and lateral roentgenogram were made at the initial visit prior to prescribing the Milwaukee brace and were compared with those made subsequently. Since follow up was made of all patients at varying intervals while they were wearing the brace, it was possible to determine the correctability of the curve which was correlated with the duration of the Milwaukee brace applied. In thirty-five patients followed for a minimum of eight months, final correction referred to the roentgenogram which showed the last correction of the major curve achieved during or after brace treatment at the time of this analysis.

Results

Thirty-five patients had been worn the brace for a minimum of eight months at the time of this analysis. Of this group, nineteen patients were still wearing their braces full time or part time and eight patients had completely weaned their braces. The remainder eight patients had to have the operation since the curves showed gradually worsened. Total angle of the curve, measured by the Cobb method, was determined at the initial and following three to six months interval

after the Milwaukee brace applied.

The initial curves in thirty-five patients with forty-four curves averaged 40.5 degrees with range of from 26 to 67 degrees, and the average obtained curve on side bending was 24.3 degrees. Final amount of correction of the curves averaged 14.1 degrees. All curves showed greater correction on side bending at the time of the initial examination than at the time of best brace correction.

The results in thirty-five patients with forty-four curves were analyzed according to the age when applied the brace, the duration of application, the etiology of the curve, the pattern of the curve, the severity of the curve prior to wearing the brace, the length of the curve, and finally corrected degrees of the curve after the application.

Table III shows the correctability of the curve according to the age at the time of the brace application. Age under sixteen years in this series did not play a significant role.

Of thirty-five patients with forty-four curves treated with the Milwaukee brace, thirty-two patients with thirty-nine curves had been worn at least eighteen months or more and were cooperated fully.

Table IV shows the average correction of

Table III. Correctability of the Curve According to the Age When Applied

Age in years	No. of Curves	Average Curves before Applied	Average Correctability on Side Bending		Average Amount of Final Correction	
			Degrees	%	Degrees	%
Less than 10	10	46.5	13.1	66.9	9.7	20.9
10~12	9	38.7	15.4	39.8	1.5	3.9
13~14	7	35.3	18.0	51.0	13.0	37.4
15~16	17	38.9	26.5	68.1	2.3	5.9
More than 16	1	59.0	46.0	74.6	9.0	15.3
Total	44	40.5	24.3	60.0	5.7	14.1

Table N. Correction of the Curve Correlated with the Duration of Milwaukee Brace Application

Duration* of Application	Average Curves Obtained	Amount of Correction	
		Degrees	%
Less than 3 months	35.9	4.3	10.8
4 to 6 months	34.8	5.4	13.4
7 to 9 months	34.3	5.9	14.6
10 to 12 months	33.8	6.4	15.9
1 to 1.5 years	33.9	6.3	15.7

* Average duration 30 months
Range from 8 months to 11 years

the curve correlated with the duration of wearing of the Milwaukee brace in thirty-nine curves, followed up for an average of thirty months. The results were 4.3 degrees (10.8%) in less than three months, 5.4 degrees (13.4%) in between three and six months, 5.9 degrees

(14.6%) in between six and nine months, 6.4 degrees (15.9%) in nine and twelve months, and 6.3 degrees (15.7%) finally. The maximum correction of the curve was obtained near at one year. Sixty-five per cent of the final correction was obtained within three months.

Table V indicates the initial curve, correction on side bending (flexibility), and final amount of correction in the different etiology. Idiopathic curve was corrected best on side bending and at the final examination. Paralytic curves were corrected less than idiopathic in spite of their flexibility. Congenital or neurofibromatosis curve was resistive with brace treatment but surgery could be postponed until the ideal time.

Table VI shows the result of treatment in the different pattern of the curve. The thoracic

Table V. Correctability Correlated with Etiology of Scoliosis by Milwaukee Brace Application

Etiology	No. of Curves	Average Curves before Applied	Av. Correctability on Side Bending		Av. Amount of Final Correction	
			Degrees	%	Degrees	%
Idiopathic	30	37.9	25.1	66.2	7.3	19.3
Paralytic	6	53.0	30.3	57.2	5.8	10.9
Congenital	7	38.6	15.9	41.2	0.9	2.3
Neurofibromatosis	1	55.0	25.0	45.5	-10.0	-18.2
Total	44	40.5	24.3	60.0	5.7	14.1

Table VI. Correctability Correlated with the Curve Pattern by Milwaukee Brace Application

Curve Pattern	No. of Curves	Average Curve before Applied	Av. Correctability of Side Bending		Av. Amount of Final Correction	
			Degrees	%	Degrees	%
Thoracic	16	40.9	23.3	60.0	8.6	21.1
Thoracolumbar	9	46.0	28.9	62.9	6.4	13.9
Double major, Dorsal	9	37.3	19.9	53.4	3.6	10.2
Lumbar	9	38.7	27.0	69.8	2.2	5.7
Lumbar	1	28.0	16.0	57.1	2.0	7.1
Total	44	40.5	24.3	60.0	5.7	14.1

Table VI. Correctability Correlated with the Severity of the Curve by Milwaukee Brace Application

Curve in Degrees	No. of Curves	Average Curves before Applied	Av. Correctability on Side Bending		Av. Amount of Final Correction	
			Degrees	%	Degrees	%
20~29	12	26.2	15.4	58.8	7.8	29.8
30~39	10	33.4	25.1	75.1	5.1	15.3
40~49	12	46.0	27.2	59.1	5.0	10.9
50~59	9	56.9	30.8	54.1	5.9	10.4
More than 60	1	68.0	32.0	47.1	-5.0	-7.4
Total	44	40.5	24.3	60.0	5.7	14.1

Table VII. Correctability According to Segments Involved in a Major Curve

Involved Segments	No. of Curves	Average Curves before Applied	Av. Correctability on Side Bending		Av. Amount of Final Correction	
			Degrees	%	Degrees	%
Less than 3	2	31.5	15.5	49.2	1.9	6.0
4~5	3	45.0	28.3	62.9	0.9	2.0
6~7	22	40.0	24.4	61.0	7.2	18.0
8~9	16	40.8	25.0	61.3	6.0	14.7
More than 10	1	48.0	18.0	37.5	-12.0	-25.0
Total	44	40.5	24.3	60.0	5.7	14.1

and thoracolumbar curves were corrected much more than those of lumbar curves. In double major curves, the thoracic curves were obtained more correction comparing to the lumbar curves. The high thoracic curve was originally excluded in the application of the Milwaukee brace.

Table VI indicates the analysis of the result according to the severity of the curve. The best correction of the curve was obtained in the curves between twenty and twenty-nine degrees. The more severe the curve at the initial examination, the less percentage of the correction was obtained finally. In a case with sixty-eight degrees initially was rather increased five degrees in the brace.

Table VII reveals the amount of correction according to numbers of the segments involved

in a major curve. The larger curve (involved over 6 segments) was resulted in significantly more correction than the smaller (less than 6 segments).

Table VIII shows the corrected degrees obtained finally. There was 36.4 percent in less than five degrees of change, and was 43.2 percent in decrease of between five and fifteen degrees. In one case the curve was increased twenty-one degrees.

Complications were rare and of little significance. Several cases of mild irritation of the skin developed over the iliac crest. These lesions were responded to the routine care without interruption of the treatment scheduled. Recently no skin problems developed by means of the orthoplast instead of the leather, and mandibular deformity and distur-

Table X. Final Correction of the Curve by Milwaukee Brace Applied Comparing to Initial Curve

Obtained Curves of Correction in Degrees	Number of Curves	
	Number	%
Decrease of greater than 25	1	2.2
Decrease of 15 to 25	3	6.9
Decrease of 5 to 15	19	43.2
Less than 5 degrees	16	36.4
Increase of 5 to 15	4	9.1
Increase of 16 to 25	1	2.2

bance of bite has been easily eliminated with the use of throat mold, not chin rest.

Discussion

Many different types of orthoses were devised to improve the plaster jacket, that had been used to hold correction of a curvature since the end of the nineteenth century. Of these, the most effective device is the Milwaukee brace. The Milwaukee brace is widely used to correct and maintain the scoliotic deformities in patients with an immature spine and a curve of mild or moderate degrees. In addition, it is also successful in halting the curve progression to which surgery is not deemed necessary at the outset of treatment^{7,10}. However, it is apparent that the use of the brace would not replace spine fusion in the management of scoliosis⁷.

The best results were obtained in early diagnosis with prompt treatment while the curve was flexible and was less than forty degrees. The younger the child, the greater was the success in non-operative treatment of almost all the spinal curves¹¹. To prevent a severe deformity, it was of importance that the public, the pediatricist, the general physician, paramedical personal, and the orthopedic

surgeon would be made fully aware of early recognition and effective treatment¹⁰.

In this country, many patients were discovered to be too late or old for the conservative care and often withheld to wear the brace for such a long time. And some patients hesitated being taken the operation in spite of physician's advice.

Most patients in this series had the more severe and rigid curvatures with an average initial curve of 40.5 degrees. But even in rather severe and rigid curvatures, the Milwaukee brace was applied and found to be usually valuable to reduce the curve progression and to postpone the spinal fusion until the operation would be more desirable.

The major variables were the etiology, the pattern of the curve, the severity of the curve, the size and flexibility of the curve, and degree of cooperation by the patients⁵.

The Milwaukee brace should be begun promptly for any structural curve below forty degrees. Mild flexible curves below twenty degrees could be treated as a postural training or other exercises. During the period of observation, signs of structural fixation and/or progression of the curve called for prompt use of the brace¹². Sometimes in the younger patients, satisfactory result might be obtained in curves of fifty or sixty degrees. As a rule single major curve of sixty or more in the older adolescent should have Harrington instrumentation and fusion¹⁰

As an application of the brace, a minimum of one year of full time treatment should be carried out before any results could be followed^(11,12). Moe and Kettleson claimed the maximal correction was obtained at five months in 32.5 percent of 169 patients and in the first two years in 97 percent of all patients^{8,9}. In this series, the maximum correction of the

curves was obtained near at one year, but much of the correction was obtained in 3 months. High thoracic curves were the most structural and gave the poorest response during the brace treatment^{5,9,11}. Thoracic curves were the most favorable for the Milwaukee brace correction and holding. Lumbar curves were corrected well with the best correction, but they were apt to lose their correction out of the brace. Double major curves were among the most ideal for non-operative treatment despite poor response to the Milwaukee brace. Balanced double major were scarcely noticeable cosmetically, even with the severe deformity of the curve over sixty degrees¹¹.

In curves of all the etiologies, the brace was effective before severe angulation developed. Idiopathic curves responded well to brace treatment. The Milwaukee brace offered the best result in adolescent and juvenile idiopathic curves below forty degrees, provided that the spine was still immature¹⁰. Congenital scoliosis such as unsegmented bars, hemivertebrae, and other curve producing anomalies were not respond well to the brace and required a short solid fusion early as a fundamental treatment¹⁰.

In paralytic scoliosis, the brace was commonly used in order to prevent severe fixed deformity or hold for severe curve after fusion.

In the treatment of the fixed pelvic obliquity in paralytic scoliosis, Irwin recommended surgical release of the contractures below iliac crest by means of simple fasciotomy. But the Irwin's idea was not uniformly fit for long standing severe cases, and which contracture, above or below iliac crest, is the primary one was uncertain in severely fixed cases. It was not opposite often but same side as that of abduction of hip, of which, lateral trunk muscle contractures prevent effective correction of fixed pelvic obliquity. If pelvic obliquity in para-

lytic scoliosis is long standing and fixed, extensive spinal fusion using Harrington rod and sacral bar will finally be mandatory. Even in paralytic scoliosis with pelvic obliquity, Milwaukee brace could be applied effectively after soft tissue release until the ideal time of spinal fusion¹⁴. Neurofibromatosis scoliosis was indicated little for the Milwaukee brace.

The exercise was also important and should be instructed in and out of the brace under supervision of orthopedic surgeon or physical therapist. Exercise consisted of general conditioning and specific movement in the brace which would reduce the major curve and increase chest expansion¹¹.

By the length of the curve, longer curve could be managed in ease and corrected better than shorter ones.

Summary & Conclusion

1. Thirty-five patients with forty-four curves were treated with a Milwaukee brace, and followed for eight months to sixty-two months with an average of thirty months after the brace application. At the time of this analysis, nineteen patients had been still wearing their brace full-time or part time. Surgical intervention were carried out during the Milwaukee brace application in eight patients.

2. The average age was 12.4 years ranging from 4.5 years to 16.3 years. The average initial curve was 40.5 degrees and the average correctability on side bending was 24.3 (60.0 %).

3. The average final amount of correction was 5.7 degrees (14.1%). The age was little significant in patients whose iliac apophyses had not capped. The average maximum correc-

tion of the curve was obtained near at one year and over sixty-five percent of all the final correction was obtained within three months

4. The thoracic and thoracolumbar curve gave the best correction. The lumbar was negligible to maintain the curve. Idiopathic curve was corrected best, and congenital and neurofibromatosis curves had poor response. Longer and mild curves was relatively corrected more and had better results.

5. The Milwaukee brace were effective in patients whose curves were mild or moderate, prior to the skeletal maturation. Severe deformities in eight young patients were kept from curve progression so that fusion could be safely delayed until a more desirable age for operation was reached. Milwaukee brace could be applied effectively even in paralytic scoliosis in young children with pelvic obliquity after soft tissue release until the ideal time of spinal fusion.

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