The Effect of the Milwaukee Brace upon Dentofacial Growth

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Scoliosis is persistent lateral curvature of the spine. It may be either postural or structural in type. In scoliosis that is due to poor posture the skeleton is normal and the curve disappears when there is no weight on the spine, for example, when the patient lies down or bends forwards. In structural scoliosis the lateral curvature is combined with rotation of vertebrae so that asymmetry of the thorax is increased and voluntary correction is impossible. Although some cases of scoliosis can be attributed to myopathic, neuropathic, or osteopathic factors, the majority of cases arise without apparent cause, indeed all of the cases in the present series were idiopathic. It has been suggested that the cause could be a neuromuscular inco-ordination in the muscles responsible for spinal posture.[1]

Clinical Features of Scoliosis

Idiopathic scoliosis is more common in girls than boys. It may appear at any age but the peak incidence of presentation is at ten years. Since pain is rarely present, the condition is usually first noticed by the parent. At first the curvature may be mild, but in severe cases there is rapid deterioration in the shape of the spine. Deterioration tends to be most marked during the period of rapid spinal growth that accompanies and precedes puberty.[2] When growth of the spine has been completed, by the age of sixteen years, the scoliosis becomes stabilized and curvature is unlikely to become worse.

Radiographic Features

The radiograph of a scoliotic spine is shown in Figure 1. The main curvature is usually to the right side in the thoracic and lumbar regions of the spine. Above and below the main curve there are commonly secondary compensatory curves that bring the head roughly above the pelvis and give an illusion of straightness in the clothed patient. Because of this, the cosmetic effect of the scoliosis may be less serious than might be thought from a consideration of the radiographs alone.

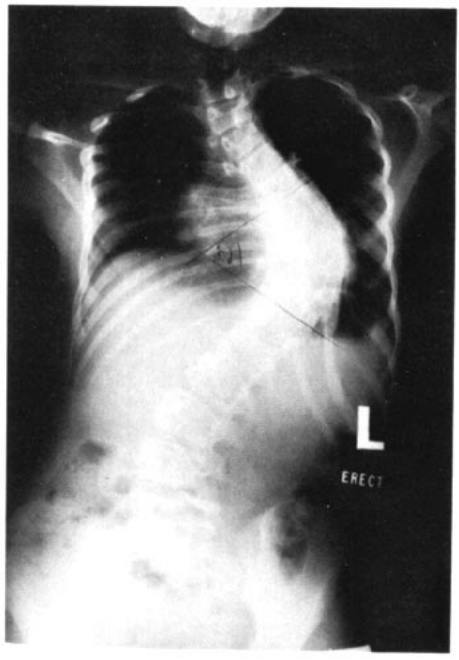

Fig. 1 P/A view of a scoliotic spine.

Orthopaedic Treatment of Scoliosis

Many cases of spinal curvature are mild and few need treatment.[1] However, the effects produced by a severely progressive structural curve may be serious. Pulmonary ventilation is im-

paired so that cardiac function is affected and right-sided heart failure may be produced. In addition, the function of other organs may be upset.

It is only in relatively recent times that the treatment of scoliosis has been rationalised. The principles of treatment are to prevent increase in the deformity, to correct it, and then to maintain the correction until the spine is stable. The only effective treatment for severe structural scoliosis is the operation of spinal fusion first described by Hibbs in 1911[3] and improved by him in 1924.[4] This operation led to renewed interest in the treatment of scoliosis and methods were developed by which the curvature could be corrected before the fusion operation was performed. The most efficient was the turnbuckle jacket first used by Lovett and Brewster[5] and later developed by Ferguson and Risser.[6] This was a rather cumbersome device and meant that the child was confined to bed for long periods.

Braces were not found to be effective in correcting curves until the Milwaukee brace was developed in 1944.[7] This is cooler, cleaner and more comfortable than the heavy jackets and has the great advantage that the patient is ambulatory. It is not as successful as the jacket for the correction of severe rigid deformities, but in average cases it is most satisfactory. A series showing the improvement that can be obtained is shown in Figures 2 and 3.

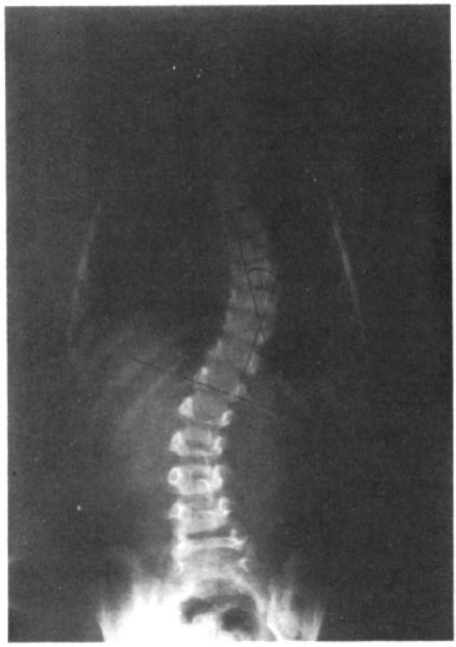

Fig. 2 Radiograph of the same patient showing improvement in the scoliosis after wearing the Milwaukee brace for one year.

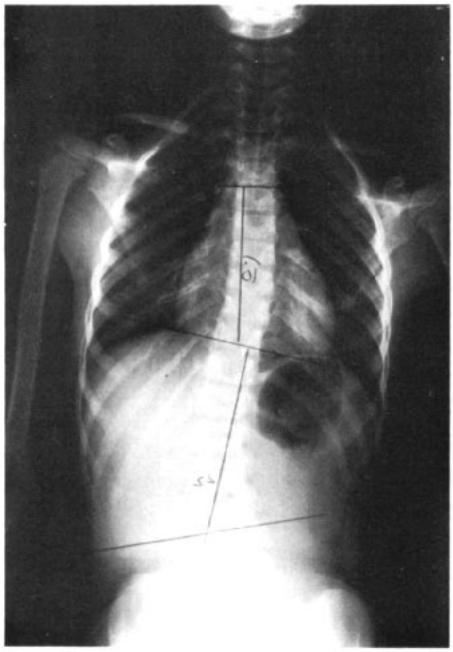

Fig. 3 The same patient three years later.

The Design and Use of the Milwaukee Brace

The Milwaukee brace was originally described by Blount, Schmidt and Bidwell.[8] The essential features are shown in Figure 4. The pelvic girdle is reinforced leather and from it adjustable struts pass upwards to carry rests for the chin and occiput. A pressure pad exerts thrust against the ribs on the convex side of the curve while a strap passing beneath the axilla supports the

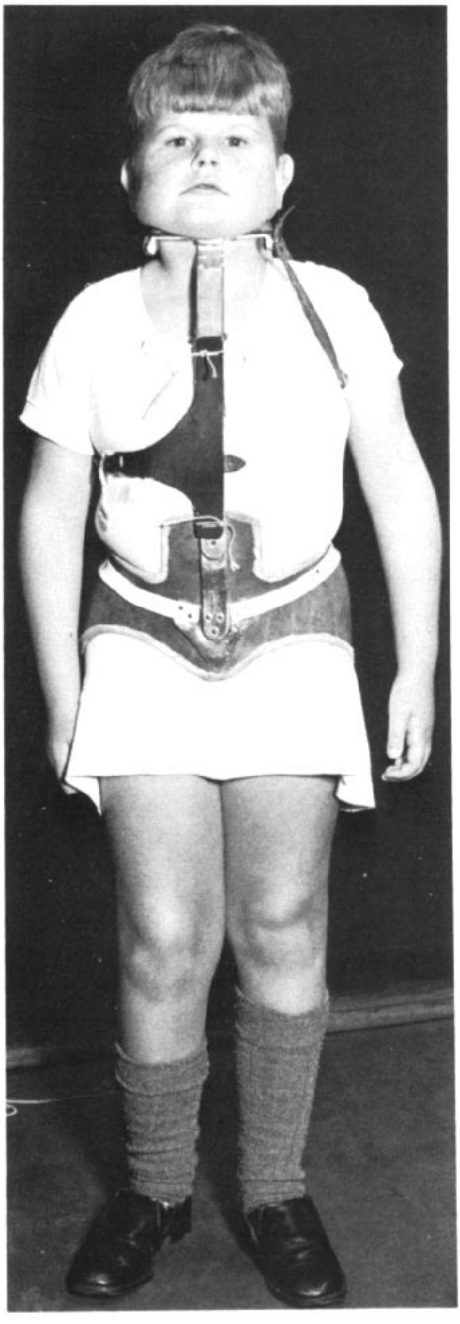

Fig. 4 A patient wearing the Milwaukee brace.

shoulder on the concave side. As described by Blount and Schmidt, there should be no forcible traction and the brace should be fitted so that both chin and occiput can be raised from the support simultaneously. "This situation must prevail at all times during and following the correction.[7]" In practice, however, this situation is rarely found and the patient tends to slump down into the brace as shown in Figure 4. The Milwaukee brace is used both preoperatively to obtain correction of the curvature and postoperatively whilst the stability of the spine is uncertain. This can mean that the brace is worn for very long periods during childhood.

Dental Effects Due to the Brace Previously Reported

The effect of even transient external pressure on the dental arches is well known. Measurable changes have been reported following pressure from a rubber ball for only a few days.[9] The average pressure exerted against the mandible by the chin rest of the Milwaukee brace has been measured in some cases to be four pounds.[10] It seems likely that such a force, applied over several years, would produce an effect upon the development of the dentition and facial skeleton. Centrifugal spreading of the maxillary arch due to collapse of the buccal wall of the alveolus has been reported.[11] The occlusal surfaces of the molars faced buccally. More frequently reported has been labial inclination of the upper and lower incisor teeth and depression of the molars and premolars.[12,13] These effects are shown in Figures 5 and 6. Reduction of the vertical growth of the lower face has also been found.[12]

In an attempt to prevent the artificial creation of malocclusion during orthopaedic treatment, rubber dental positioners made to a resting bite have been used.[14] These may be of value, but they present the patient with an additional

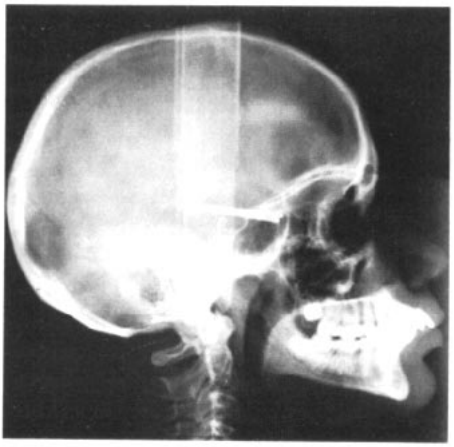

Fig. 5 Lateral skull radiograph of a patient aged 16 years who has worn the Milwaukee brace for 9 months showing abnormal proclination of upper and lower incisor teeth.

appliance that must be worn and tolerance may not be good.[12] Hitchcock describes the construction of a positioner by cutting teeth off duplicate models and setting them up in wax to a better position. The malocclusion was treated in stages using several positioners but, even so, root resorption was found that could possibly have been due to excessive force.

The Present Study

This paper presents the results of a cephalometric investigation into the effects of wearing the Milwaukee brace upon the growth of the facial skeleton

Fig. 6 Dental models of the patient illustrated in Figure 5.

and the form of the dentition. Through the generous help of surgical and nursing staff, patients were seen at a special Scoliosis Clinic held each month at the Outpatients Department of the Royal Orthopaedic Hospital, Birmingham. Scoliotic patients from a wide area of the West Midlands attend this clinic for review and for periodic adjustment of their appliances. The normal period between appointments is four to six months.

Lateral skull radiographs of twenty-five patients wearing the Milwaukee brace were taken using an Adams cephalostat. Fourteen patients were female and eleven male. The ages ranged from 5 to 19 years, with the average age at almost exactly 10 years. The patients had worn a Milwaukee brace for periods ranging from over 7 years to only 2 months, the average period of wear being 2 years, 4 months.

Lateral skull radiographs to form a control group were selected from patients attending the Children's and Conservation Departments of Birmingham Dental Hospital. Orthodontic Department patients were not used as these were considered to be a selected sample. Each radiograph from the study group was matched for age and sex with a control.

Eleven measurements were taken from each radiograph, six were linear and five angular. A tracing is represented diagrammatically in Figure 7. The points and planes used were as defined by Graber,[15] except for the lower end of the facial plane which was taken as menton rather than pogonion. The measurements were:

1. Total face height—the length along the facial plane from nasion to menton—A
2. Upper face height—the length along the facial plane from nasion to the point of intersection of the palatal plane—B

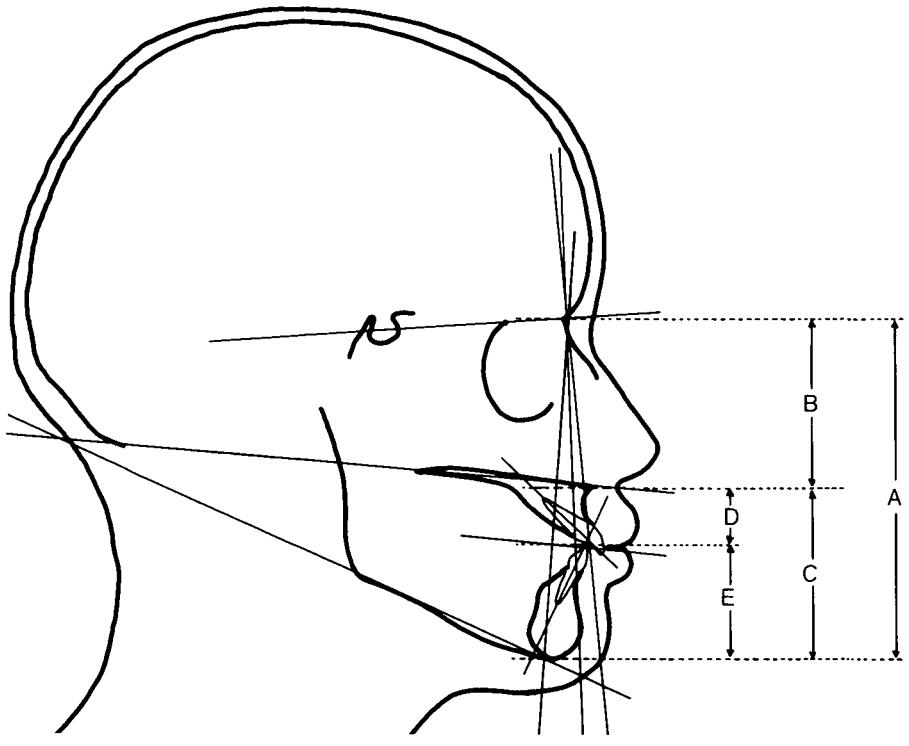

Fig. 7 A lateral skull radiograph tracing showing the vertical measurements taken from the facial skeleton.

3. Lower face height—the length along the facial plane from the point of intersection of the palatal plane to menton—C
4, 5. Upper and lower dental height—lower face height was divided into upper and lower dental heights by the intersection of the occlusal plane with the facial plane—D and E
6. Maxilla length—the length of the palatal plane between the points of intersection of perpendiculars from point A and the lowest point on the pterygomaxillary fissure.
7. Angles—lower incisor with the mandibular plane, LIA; upper incisor with the palatal plane, UIA; SNA, SNB and gonial angles.

Results

The paired sets of measurements for study and control groups were analyzed using a paired "t" test. Results of the analysis are shown in Table 1.

All vertical measurements on the size of the facial skeleton showed significant differences between the study and control groups, differences being due to smaller values in the study group. This was a consistent finding, total face height being less in the study group than the control group in all except two cases. The greatest difference found was 13 mm with the mean at 7.70 mm.

The one horizontal measurement made was maxilla length. There was no significant difference between the two groups for this measurement; in fact, values obtained were almost identical with a mean difference of only 0.04 mm.

There was no significant difference between the angulations of the upper and lower incisors in the two groups.

TABLE I

	Mean Diff.	Variance of Diff.	St. Dev. of Diff.	St.-Error of Diff.	"t" value
Total face height	—7.70	41.70	6.45	1.29	—5.96***
Upper face height	—3.50	13.25	3.64	0.72	—4.86***
Lower face height	—4.46	33.43	5.78	1.15	—3.87***
Upper dental height	—2.35	11.79	3.43	0.70	—3.35**
Lower dental height	—2.13	14.33	3.79	0.77	—2.75*
Maxilla length	0.04	0.11	0.34	0.07	0.70
LIA	19.58	3951.06	62.86	12.83	1.53
UIA	4.96	245.95	15.68	3.20	1.55
SNA	3.7	22.96	4.79	0.96	3.86***
SNB	1.98	22.74	4.77	0.95	2.08*
Gonial angle	—2.16	56.33	7.51	1.50	—1.44

* $P < 0.05$
** $P < 0.01$
*** $P < 0.001$

Values for both angles SNA and SNB were significantly greater in the study group. The larger difference in SNA was found not to be significant when study and control group values for each angle were compared using an unpaired "t" test.

Discussion of Results

No pretreatment records were available for the study group and it cannot be certain that the two groups were identical before treatment of the study group. However, statistical comparison of vertical measurements for the study and control groups showed the differences between the two groups to be highly significant. On the other hand, the maxilla lengths of the two groups were almost identical with a mean difference of only 0.04 mm.

Therefore, there is strong evidence that the effect of the Milwaukee brace is to reduce the vertical dimension of the facial skeleton during the period that the brace is worn. The four measurements, which together constituted total face height, were smaller in similar proportions in the study group with no individual measurement showing a disproportionate difference.

Interpretation of some of the angular measurements was more difficult owing to the high variances found within the samples. Variances were particularly high for the upper and lower incisor angulations. It has previously been reported that the incisor apices may be difficult to locate on a lateral skull radiograph so that values obtained for the axial inclinations of the incisors can be unreliable.[16] An attempt was made to compare incisor angulations between the two groups in this study since increase in the values has so frequently been reported after wearing of the Milwaukee brace. Neither upper or lower incisor angulation was significantly greater in the study group according to the "t" value. However, if the mean differences for the incisor angulations are considered, it is found that the lower incisors in the study group were proclined on average 19.58° more than those of the control group. Average proclination of the upper incisors of the study group was 4.96° more than the control group with the highest value at 141° to the maxillary plane.

Summary

Measurements taken from a series of twenty-five lateral skull radiographs of patients who had worn the Milwaukee brace for varying periods were compared with measurements taken from radiographs of control patients matched for age and sex. The findings were as follows:

1. All vertical measurements on the facial skeleton were significantly lower in the study group. Differences were proportionate for each part of the facial skeleton.
2. Maxilla length was almost the same in the two groups, the mean difference being only 0.04 mm.
3. Angles SNA and SNB were both significantly greater in the study group.
4. Although some of the patients in the study group showed markedly greater incisor proclination than the controls, over the groups as a whole this was not statistically significant.

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References

1. Gruca, A. The pathogenesis and treatment of idiopathic scoliosis. *J. Bone and Joint Surg.* 40A:570-584, 1958.
2. Smith, A. D. Editorial. *J. Bone and Joint Surg.* 40A:505, 1958.
3. Hibbs, R. A. An operation for progressive spinal deformities. Preliminary report. *N.Y. Med. J.* 93:1013-1016, 1911.
4. ————. 59 cases of scoliosis treated by fusion operation. *J. Bone and Joint Surg.* 6:3-37, 1924.
5. Lovett, R. W. and Brewster, A.. H. The treatment of scoliosis by a different method from that usually employed. *J. Bone and Joint Surg.* 13: 91-104, 1924.
6. Hibbs, R. A., Risser, J. C., and Ferguson, A. B. Scoliosis treated by the fusion operation. An end result study of 360 cases. *J. Bone and Joint Surg.* 13:91-104, 1931.
7. Blount, W. P., Schmidt, A. C., Keever, E. D., and Leonard, E. T. The Milwaukee brace in the operative treatment of scoliosis. *J. Bone and Joint Surg.* 40A:511-525, 1958.
8. Blount, W. P., Schmidt, A.. C., and Bidwell, R. G. Making the Milwaukee brace. *J. Bone and Joint Surg.* 40A: 526-528, 1958.
9. Kjellgren, B. Experiments concerning the influence of external pressure on the occlusion. *Dent. Cosmos.* 68: 705-708, 1926.
10. Logan, W. R. Dental effects due to the Milwaukee brace. *Trans. Europ. Orthod. Soc.* 217, 1962.
11. ————. The effect of the Milwaukee brace on the developing dentition. *Dent. Pract. Dent. Rec.* 12:447-454, 1962.
12. Alexander, R. G. The effects on tooth position and maxillofacial vertical growth during treatment of scoliosis with the Milwaukee brace. *Am. J. Orthod.* 52:161-189, 1966.
13. Hitchcock, H. P. Treatment of a malocclusion associated with scoliosis. *Angle Orthod.* 39:64-68, 1969.
14. Bunch, W. B. Orthodontic positioner treatment during orthopaedic treatment of scoliosis. *Am. J. Orthod.* 47: 174-204, 1961.
15. Graber, T. M. Implementation of the roentgenographic cephalometric technique. *Am. J. Orthod.* 44:906-932, 1958.
16. Mills, J. R. E. The stability of the lower labial segment. *Dent. Pract. Dent. Rec.* 18:293, 1968.