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Incidence of surgery in conservatively treated patients with scoliosis

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Summary

The effectiveness of bracing and the effectiveness of conservative treatment of scoliosis as a whole is widely denied and rejected. We therefore carried out the present study in order to establish whether the work involved in the conservative treatment of scoliosis is reasonable and worthwhile, including as it does the education of patients, techniques of brace moulding, time-consuming follow-ups and the strain put on patients by the treatment itself. *Study design*: A retrospective analysis of the incidence of surgery in patients with scoliosis presenting every kind of aetiology. To improve comparison with data already published by other centres, this group of patients was matched with the study design of the control group. *Materials and methods:* Since 1992, in addition to the intensive inpatient rehabilitation programme developed at our centre, we have also been practising moulding techniques according to Chêneau in order to construct scoliosis orthoses of high correction. For the purposes of this study we chose a number of scoliosis patients from our data bank who had had conservative treatment at our centre between 1993 and 1996. All the patients, like those of the untreated control group, were at least 15 years of age at the time they were last investigated or questioned. The incidence of surgery in our group was compared statistically with data published by other centres. *Results:* Three hundred and forty-three patients (females only) with a curvature of 33.4° (SD = 18.9) were included in our study and could be followed up under the described pre-conditions. Forty-one patients (11.95%) had had surgery. In patients with adolescent idiopathic scoliosis, we found an incidence of surgery of only 7.3% compared with 28% in the control group with the same diagnosis. Statistically, therefore, the incidence of surgery in our group was highly significantly lower than the incidence of surgery in the control group from Ireland and other centres described in literature. *Conclusions:* The conservative treatment of scoliosis (which includes outpatient physiotherapy, inpatient intensive scoliosis rehabilitation (SIR) and high-correction-effect bracing based on plastercasting) shows an obvious reduction in the rate of surgery in patients with idiopathic scoliosis compared with untreated scoliosis patients. Thus it can be seen that the conservative treatment of scoliosis may reduce the incidence of surgery, which not only causes considerable medical expenses but also carries with it the risk of repeated operations and further complications. In our study, we also found highly significant differences by comparison with the work of a bracing centre in the USA. Therefore, the quality of the bracing itself and the effects of primary correction must receive greater consideration in future scientific studies on the subject of 'conservative' treatment of scoliosis.

Introduction

On the one hand the literature confirms the effectiveness of certain orthoses in the treatment of scoliosis [1, 2] and yet on the other hand their effectiveness is generally denied and the treatment is widely rejected [3, 4]. Although conservative methods of treatment with physiotherapy and braces are generally accepted in central Europe [5, 6], conservative treatment in the USA is largely discounted. In addition to the language barrier, which is so prejudicial to the English-speaking countries in that it reduces the availability there of up-to-date information about conservative methods of treatment of scoliosis, a number of mistaken and unhelpful ideas even exist in the practice of this treatment which, far from being beneficial to patients, may actually put strain on them [7].

In Germany, conservative treatment (including brace treatment and physiotherapy) is regarded as effective if a curvature shows no further progression (even when further growth is expected) or if there is a clear tendency towards a decreasing curvature. Hanks *et al.* [7] nevertheless speak of successful brace treatments in the USA, provided that the increase of the curvature

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is no greater than 10° [7]. However, that study fails to draw attention to the corrective effect of an orthosis, an aspect that its authors do not even mention. Moreover, other widely used ideas for treatment with orthoses, for example the Milwaukee brace [8], have proved to be ineffective by comparison with the effectiveness of the braces used in central Europe because their corrective effect has been too low to show any positive end result [9]. Based on our own review of the literature, we were able to prove that there does indeed exist a direct positive correlation between the primary effect of an orthosis and the end result [10]. In his study of the treatment of idiopathic scoliosis with the aid of the Chêneau brace, Landauer [2] also concluded that compliance on one hand and the primary effect of the brace on the other are the main parameters of successful brace treatment.

In the USA, however, braces are not very often 'custom made'. They are sometimes able to achieve a corrective effect of 50% in relation to the initial curvature, but only on smaller curves, and thus may indeed exercise an essential influence on the final prognosis [11]. This shows that the question of the effectiveness or not of conservative treatment in general, and of scolioses orthoses in particular, is very complex and cannot be answered on a one-dimensional basis. By contrast, the treatment of scoliosis with the Chêneau brace is currently most practised in Germany [12]. The clinical histories of individuals enjoying excellent corrective effects and favourable outcomes are encouraging the use of this method there (figure 1). We must emphasize nevertheless that how ever well adjusted an orthosis may be, there do indeed exist curvatures whose progression cannot be halted. And so we ask the following questions: Are our efforts reasonable and worthwhile, involving as they do the time-consuming education of patients, moulding techniques and follow-ups, and the strain put on patients by all the conservative methods? Or should we follow the American way of scoliosis treatment, i.e. wait until the scoliosis has to be corrected surgically?

In a recent study, Goldberg *et al.* [4] analysed the incidence of surgery in patients with adolescent idiopathic scoliosis at several centres in which a comparison between the incidence of surgery in braced patients and the incidence of surgery in non-braced patients was

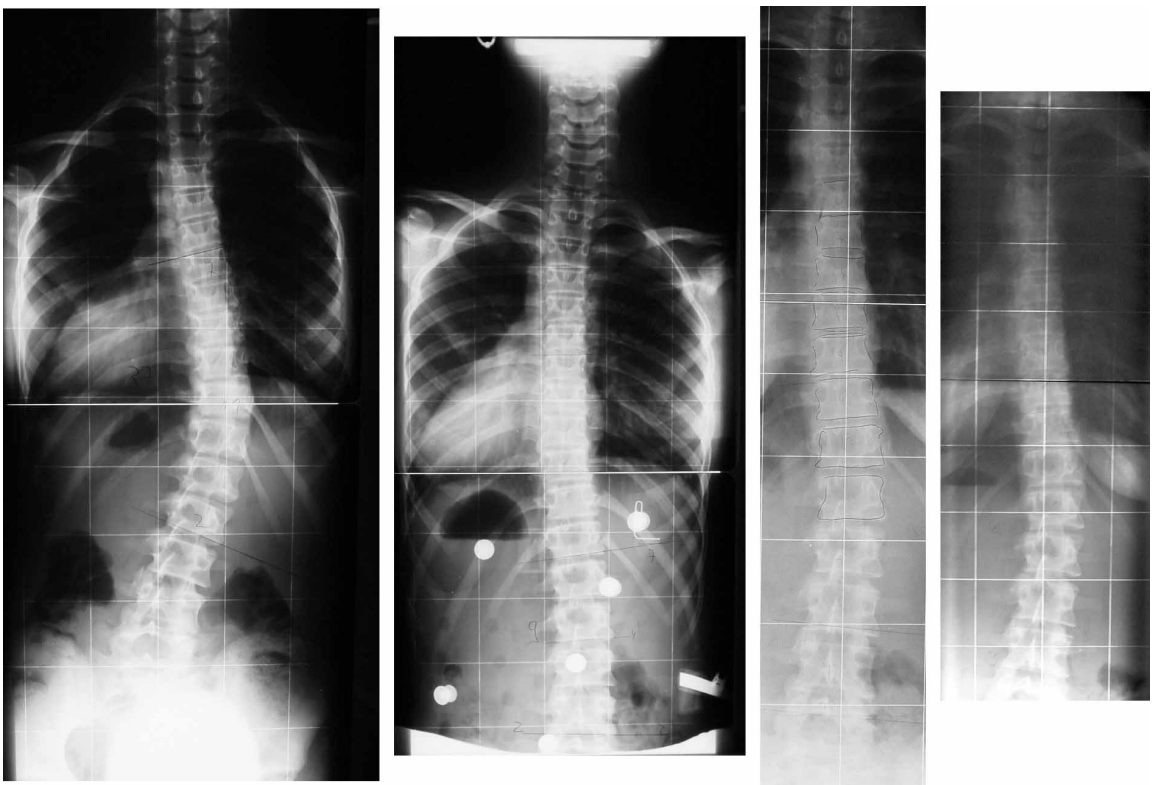

Figure 1 (*a*) Cobb angle before brace treatment of 37° in 13-year-old girl with a low thoracic curve (with thoracic flatback), (*b*) in the brace with an over-correction to −16°, (*c*) 14° directly after weaning off the brace, and (*d*) 18 months after weaning off 16° at the age of 19.

made. The study concluded that, as far as the number of surgical interventions was concerned, from a statistical point of view, patients who used a Milwaukee brace in the years between 1950 and 1970 did not differ from untreated patients in the 1990s. Although the methodology of this study showed some weaknesses [6], it has enabled us to use the collective of Goldberg *et al*. [4] as a control group for a retrospective study of our own.

In the non-operative treatment of scoliosis, a great number of individual factors play an important role, as already noted by Goldberg *et al*. [4]. In cases of adolescent scoliosis, surgery is normally a cosmetic indication [4], and so patients may decide for themselves what treatment they want to follow. The conservative route of treatment is time consuming and also demands restrictions on life-style, whereas surgical intervention will not take much time and may also have excellent cosmetic results.

When offered all the information available about conservative treatment and surgical intervention, many adolescent patients, even those with curvatures of over 40°, nevertheless opt for conservative treatment. Thus, in order to be able to explain to patients whether conservative treatment is a reasonable procedure or not, we have felt it desirable to make a study of the effectiveness or not of an out-patient programme of physiotherapy, in-patient intensive scoliosis rehabilitation and brace treatment (figures 2 and 3).

Scoliosis in-patient rehabilitation (SIR)

SIR employs an individualized exercise programme combining corrective behavioural patterns with physiotherapeutic methods. The exercise programme is based on sensomotor and kinesthetic principles, and its goals are: (1) to facilitate correction of the asymmetric posture; and (2) to teach the patient to maintain the corrected posture in daily activities.

A 4-week minimum stay is required for the first treatment, and may be up to 6 weeks, depending on prognosis; return treatments are 3–6 weeks in length, depending on symptoms and prognosis. Patients are admitted in groups, with the first day of the programme devoted to diagnosis and evaluation of

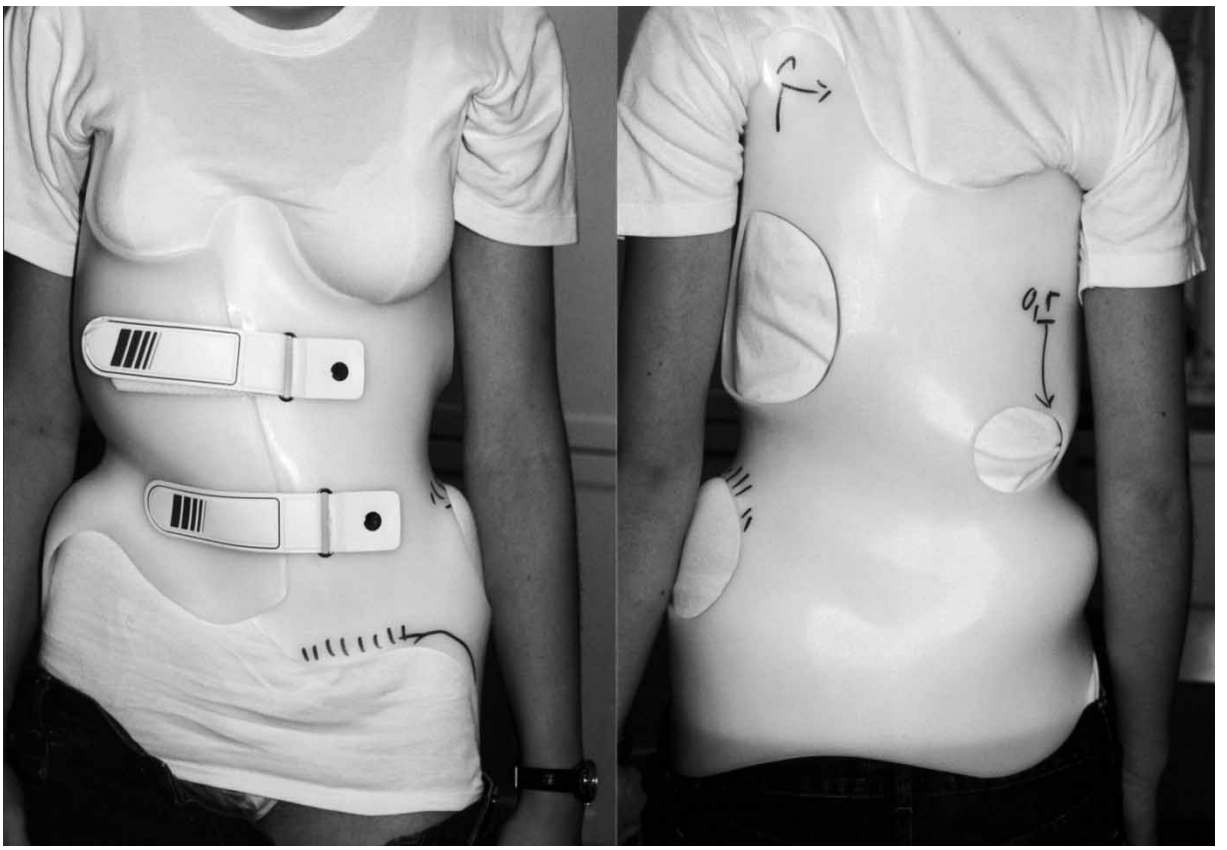

Figure 2 Chêneau brace from the rear view

Figure 3 Deflection/derotation brace from our centre with improved correction effect.

the three-dimensional deformity, supervised by seven staff physicians (two orthopaedic surgeons, and seven general practitioners or specialists in physical medicine and rehabilitation), who also provide oversight for each patient's programme. On the second day, instruction in basic human anatomy, spinal deformity and principles of postural balancing therapy is provided to the group. Each patient receives a detailed summary of his/her own condition, and those with matching diagnoses (based on age, degree and pattern of curvature) work together in groups. Evening and weekend social activities provide a sense of community and foster development of psychological support systems that can be maintained after treatment is complete.

The treatment programme consists of correction of the scoliotic posture with the help of proprioceptive and exteroceptive stimulation, and begins on the third day after admission. Each weekday, after a 20-min group warm-up session, the patients exercise in matched groups for 2 h in the morning and 2 h in the afternoon and receive shorter more individual training sessions in between. Central to the individual and group exercise programmes is therapist assistance, by a staff of 20 physical and sports therapists, who supervise all exercises and provide exteroceptive stimulation needed to obtain desired correction. Depending on individual curve patterns, the patients are assigned to special exercise groups for an additional 2 h daily. Development and maintenance of the corrected posture is facilitated using asymmetric standing exercises designed to employ targeted traction to restore torso balance and mobility. Rice-bag bolsters provide localized sustained pressure during floor exercises for mobilization of rib prominences or other torso and lumbar asymmetries. Bracing (since 1992) is applied as indicated (depending on actual growth velocity, curvature pattern, curve flexibility, and Cobb angle).

Materials and methods

In order to answer the question as to whether conservative methods (out-patient physiotherapy, in-patient intensive rehabilitation (SIR) and brace treatment—in this case mainly the Chêneau brace) are effective, we compared the incidence of surgery in patients presenting various kinds of aetiology treated at this centre with the incidence of surgery as that reported by Goldberg *et al.* [4] in patients without conservative management. In the Goldberg *et al.* [4] study, the criteria for inclusion were:

1. Diagnosis of adolescent idiopathic scoliosis;
2. Minimum age of 15 years at last check-up (not younger than 10 years at first check-up);
3. Documentation for Cobb angle without brace at first check-up (at least 10°).

Curve pattern distribution was given for the whole collective. In girls, menarchial status and the incidence of surgery were also known.

In order to be able to compare the patients at our centre who had had one or more in-patient intensive courses of rehabilitation (with or without a brace; see figure 4) with the collective of Goldberg *et al.* [4], we followed their study design. All patients (girls only in our study, aged between 10 and 13 years) diagnosed with scoliosis of every kind of aetiology, and who had attended our centre between 1993 and 1996, were included in this study. As not all patients in this group had had repeated treatment at our centre or had had only out-patient appointments elsewhere, the study was conducted by means of a questionnaire. Six hundred and eighty-nine patients were sent questionnaires by mail. The number of responses

Figure 4 Patients exercising in special groups with similar curve pattern to learn how to control their curves by themselves. Mirror monitoring is of importance to see and feel simultaneously the postural corrections.

was low—only 214 questionnaires were returned. We could not, therefore, present any convincing results with this group, and so all patients who failed to answer our questionnaire received a phone call and after contact were sent the questionnaire for a second time. In this way we were able to reach 343 patients out of the described group. All others had moved away from their original addresses.

The average angle of curvature according to Cobb before the first in-patient intensive course of rehabilitation was 33.4° (SD = 18.9), which was comparable to the angle of curvature evaluated by Goldberg *et al*. [4] (33°). The distribution of the pattern of curvature was as follows:

1. Thoracic scolioses: 35%
2. Double major scolioses: 37.2%
3. Lumbar scolioses: 10.2%
4. Thoracolumbar scolioses: 17.2%

Two hundred and forty-four (71%) of the patients studied wore braces. Of these, 235 also gave details of how long they wore their braces for. Fifty-eight patients (25%) wore the brace for up to 8 h daily, 47 patients (20%) for up to 16 h, 54 patients (23%) 16–21 h, and 76 patients (32%) more than 21 h daily. In surgically treated scoliosis patients ($n = 41$) the angle of curvature according to Cobb was 50° (SD = 25.4). Table 1 shows the distribution of the whole collective into different types of scoliosis.

Table 1 View of diagnoses, Cobb angles and incidence of surgery in the whole collective for adolescent idiopathic scolioses (AIS), early-onset scolioses (EOS), kyphotic scolioses (KS), congenital scolioses (CS) and other aetiologies

Diagnosis	*n*	*Cobb (°)*	*SD*	*OP (n)*	*OP(%)*
$AIS^{11—14}$	159	32.6	14.6	11	6.9
$AIS^{9/10}$	20	29.5	14.2	2	10.0
AIS^{all}	179	32.2	14.6	13	7.3
EOS	106	35.2	21.8	22	20.8
KS	38	24.4	23.6	1	2.64
CS	9	52.6	38.7	2	22.2
Others	11	37.1	13.1	3	27.3

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Results

Patients treated with a programme of intensive SIR showed an incidence of surgery of 11.95%; the patients in the Goldberg collective, however, showed an incidence of 28.1%. The differences are statistically highly significant.

Out of the first 214 patients who sent back completed questionnaires, 11% had been treated surgically, whereas out of the 343 patients who were finally included in the study, 41 had had surgical treatment. There was no statistical difference between the incidence rate reported in the questionnaires returned initially and the incidence of surgery in the whole collective. A one-tailed *t*-test was used for the comparison of two independent proportions [13]. Using this method

of testing, highly significant differences were shown ($t = 3.995$, $p < 0.0001$, $a = 0.05$) by reference to Goldberg's collective (no brace treatment, incidence of surgery 28.1%, $n = 153$). Comparing this value with the Milwaukee-braced control group of Lonstein and Winter [14] (incidence of surgery 22.4%, $n = 1020$) a highly significant difference was also evident ($t = 4.7553$, $p < 0.0001$, $a = 0.05$).

The differences by reference to the control group with brace treatment as studied by Noonan *et al.* [15] (surgery incidence 31%, $n = 88$) reveal a similarly high significance. There was a probability of error of $p = 0.0001$ with a t-value of 3.6329.

When comparing the diagnosis-matched patient groups (adolescent idiopathic scoliosis: Goldberg $n = 153$, incidence of surgery 28.1% vs Weiss $n = 179$, incidence of surgery 7.3%) we found a t-value of 5.05 with a probability of error of $p < 0.0001$ ($\mu = 0.005$).

The incidence of surgery with regard to different aetiologies is shown in table 1. Based on our experience with more than 2800 cases of scoliosis per year, we feel that adolescent idiopathic scoliosis should not be considered as a uniform condition. With this in mind, we have been distinguishing over the past 10 years between early adolescent idiopathic scoliosis with its first onset at the age of 9 or 10 years and later adolescent idiopathic scoliosis beginning at the age of 11. For this reason we have made a subdivision in table 1, since in scolioses with early beginnings a more unfavourable course of evolution has to be expected.

In comparing the early-onset scolioses in our own collective (infantile idiopathic scoliosis and juvenile idiopathic scoliosis) with the more benign patients having adolescent idiopathic scoliosis in the Goldberg collective, we found no significant differences (with a probability of error of $p = 0.087$). Had there been a larger number of cases, however, the limit of significance would also have been passed.

Patients with adolescent idiopathic scoliosis present an incidence of surgery of slightly over 7%. Patients with kyphoscoliosis show an incidence of surgery of 2.6%. Thus, patients with adolescent idiopathic scoliosis present the less favourable form of scoliosis compared with that of kyphoscoliosis.

Table 2 Distribution of pattern of curvature in idiopathic scoliosis

Diagnosis	*Thoracic (%)*	*Double major (%)*	*Lumbar (%)*	*Thoracolumbar (%)*
AIS	31	40.0	11.7	17.3
EOS	32	37.7	13.2	17.9

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Discussion

Scoliosis is a very variable condition as can be seen in the attempts made to classify it according to the various categories. Clinically, patients present with a wide spectrum of curves, particularly if they are referred from a school screening programme, employed for early detection of potential problems in the UK and in the USA. This can lead to overloading of clinics with curves of minor magnitude, which probably do not need treatment. Referrals to our centre, however, are from spine centres, general orthopaedic surgeons, paediatric physicians and general practitioners. Therefore the patient sample is pre-selected with bad prognosis.

The comparison of the study group with a totally different population might seem inappropriate; Goldberg *et al.* [4], however, also compared groups from different populations (Ireland and USA) and from different decades (braced population from the years 1950 to 1970 compared with a natural history population without treatment from the 1990s). Our study group is from the same decade as the control group and so is comparable to the Goldberg sample [4]. The comparison of patient samples out of different populations only seems to play a minor role and does not question the conclusions drawn [4].

In their introduction, Goldberg *et al.* [4] cited two references [11, 16] in which a good compliance of the patients favoured the outcome of bracing. However, they omitted the important point that in the study by Emans *et al.* [11] the actual extent of the corrective effect is also described as an essential criterion in successful bracing. This is supported by the study by Mellerowicz *et al.* [17] and the research done by Landauer [2]. The importance of the corrective effect is also confirmed by a review of the literature [10]. The study by Nachemson and Peterson [1] also proves the effectiveness of bracing. Certainly, Thulbourne and Gillespie [18] are right in saying that even if the progression can be reduced by bracing, cosmetic appearance and the rib hump may not always be influenced positively, nor may a successful course as shown by X-ray always be appreciated as a successful treatment by the patient. Nevertheless, one must point out that neither self-image nor other psychological factors can be affected by surgical treatment either [19]. Bettany *et al.* concluded that 6 months after surgery, levels of pain and emotional problems connected with scoliosis remain unaltered by most surgical techniques; and the

cosmetic results directly obtained by surgery are not necessarily stable later on either. One year after surgery a good cosmetic initial result may deteriorate and a reduced rib hump may become clearly evident again [20]. Goldberg *et al.* [4] considered that not only has the Cobb angle to be taken into account in cases of surgical treatment, but cosmetic appearance and the chances of obtaining a visible improvement have also to be appreciated.

It was interesting to note that the (female) patients in our collective who had undergone surgical treatment had been mainly urged to do so by a physician. At least 30 patients out of 36 surgically treated patients underwent surgery because their physicians had advised them to do so and not because of any wish of their own. Thus, it is seen that any decision to have surgical treatment can also be influenced by the surgeons themselves. We know from experience that, unfortunately, German patients with adolescent idiopathic scoliosis are nowadays not the only ones to be told that in the future they will have to suffer pain and that they risk the collapse of their spines and will probably be forced into a wheelchair. Such patients are also often told that their health is threatened by cor pulmonale. However, as early as 1969, Collis and Ponseti [21] reported that patients with idiopathic scoliosis do *not* in fact suffer from back pain any more frequently than a healthy control group. Pehrsson *et al.* [22] stated that patients with adolescent idiopathic scoliosis do *not* in fact die earlier compared with a healthy control group—and so far there has been not a single case of untreated adolescent idiopathic scoliosis recorded in the literature in which the patient ended up in a wheelchair because of the curvature [23].

The collective of 343 patients that we studied showed a highly significantly lower incidence of surgery than the untreated Goldberg group [4] or Lonstein and Winter's group [14] treated with the Milwaukee brace. Patients who had conservative treatment following our methods followed at least one in-patient intensive rehabilitation programme of 4–6 weeks and, if necessary, had brace treatment using the German quality criteria for brace treatment.

Contrary to Goldberg *et al.* [4] in her study, we included patients in our collective who presented all kinds of aetiology and exclusively scolioses in girls with a more unfavourable history in general [24]. The level of incidence of surgery for all aetiologies remained below the level reported by Goldberg *et al.* [4] for patients with adolescent idiopathic scoliosis. The diagnosis-matched group (adolescent idiopathic scoliosis) presented a surgery rate of slightly over 7%, and thus remained clearly below the rate of incidence of surgery in Goldberg *et al.* Thus no statistical test was required. Distribution of the pattern of curvature of more than 70% thoracic, or double major curves (table 2), showed that the conservative treatment group was not the group with the most favourable history [24]. This is also evident from a comparison of the angle of curvature in the control group with that of the treatment group.

In comparing the collective of patients suffering from early-onset scolioses (infantile idiopathic scoliosis, juvenile idiopathic scoliosis) with Goldberg's collective suffering from adolescent idiopathic scoliosis, we found no statistically significant differences. However, we did find important medical differences. Even the group of patients with early-onset scolioses (a condition that normally has the most unfavourable history) presented better results thanks to conservative scoliosis treatment than Goldberg *et al.*'s collective, which, as far as prognosis is concerned, was the more favourable group.

Is the reason for the less favourable results obtained in patients conservatively treated in the USA perhaps due to the fact that there is not sufficient control of the quality of treatment in the methods applied? In any case, it is obvious that conservative methods of treatment should never be ruled out from scoliosis treatment because these can and do offer a viable alternative to those patients who cannot or do not wish to opt for surgical treatment.

However, the study by Goldberg *et al.* [4], though suitable as a control group for our conservatively treated group of patients, has to be examined more closely for its value as a positive statement. According to the manual [25] used by Goldberg *et al.*, the validity of statistical test methods should be approached more cautiously when confirming the H_0-hypothesis (non-significant differences). Distinction must be made between the statistical statement itself and its medical relevance. Assessment of this statistical data suggests that the non-significant differences reported can in no way be regarded as proof of the ineffectiveness of the method of treatment. The statement succeeds only in proving that in that particular study and in the conditions described, no significant differences could be found. The statistical data of the statement are therefore clearly distinct from any medical relevance they may have to an evaluation of the results of the study in general. Even when following this, the manual [25], a different interpretation from that of Goldberg *et al.* may be placed upon the outcome by highlighting the fact that medically relevant differences were certainly found between the untreated control group,

with an incidence of surgery of more than 28%, and the brace group treated with the Milwaukee brace with an incidence of surgery of only 22.4%. This is reason enough to believe that treatment involving bracing with a Milwaukee orthosis does indeed have some effect. However, to conclude from a study that used only one brace (outmoded by today's standards!), that bracing with any kind of bracing system should be rejected, simply does not stand up against the scientific evidence.

Conclusions

Conservative methods of treatment with out-patient physiotherapy, in-patient intensive rehabilitation and high-correction braces have clearly proven their effectiveness in reducing the incidence of surgery in female patients with idiopathic scoliosis.

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References

1. Nachemson, A. L. and Peterson, L. E.: Effectiveness of treatment with a brace in girls who have adolescent idiopathic scoliosis. *Journal of Bone Joint Surgery* [*America*], **77**: 815–822, 1995.
2. Landauer, F.: Ist die Therapie mit dem Chêneau-Korsett wirksam? In: A. Imhoff (editor) *A (Hrsg) Fortbildung Orthopädie—Die ASG-Kurse der DGOT, Bd. 2*: *Wirbelsäule* (Darmstadt: Steinkopff), pp. 31–38, 1999.
3. Goldberg, C. J., Dowling, F. E., Hall J. E. *et al.*: A statistical comparison between natural history of idiopathic scoliosis and brace treatment in skeletally immature adolescent girls. *Spine*, **18**: 902–908, 1993.
4. Goldberg, C. J., Moore, D. P., Fogarty, E. E. and Dowling, F. E.: Adolescent idiopathic scoliosis: the effect of brace treatment on the incidence of surgery. *Spine*, **26**: 42–47, 2001.
5. Bauer, R., Kerschbaumer, F. and Rehart, S.: Skoliose. In: C. J. Wirth (editor) *(Hrsg.) Praxis der Orthopädie, Bd. 1: Konservative Orthopädie* (Stuttgart: Thieme), pp. 498–502, 2001.
6. Weiss, H. R.: Letter to the editor. *Spine*, **18**: 2058–2059, 2001.
7. Hanks, G., Zimmer, B. and Nogi, J.: TLSO treatment of idiopathic scoliosis—an analysis of the Wilmington jacket. *Spine*, **13**: 626–629, 1988.
8. Blount, W. and Moe, J.: *The Milwaukee-Brace*, 2nd edn (Baltimore: Williams & Wilkins), 1980.
9. Heine, J. and Götze, H. G.: Endergebnisse der konservativen Behandlung der Skoliose mit dem Milwaukee-Korsett. *Zeitschrift für Orthopädie und ihre Grenzgebiete*, **123**: 323–337, 1985.
10. Weiss, H. R.: Standard der Orthesenversorgung in der Skoliosebehandlung. *Medizinisch-Orthopädische Technik*, **115**: 323–330, 1995.
11. Emans, J. B., Kaelin, A., Bancel, P. *et al.*: The Boston bracing system for idiopathic scoliosis. Follow-up results in 295 patients. *Spine*, **11**: 792–801, 1986.
12. Weiss, H. R., Rigo, M. and Chêneau, J.: *Praxis der Chêneau-Korsettversorgung in der Skoliosetherapie* (Stuttgart: Thieme), 2000.
13. Bland, M.: *An Introduction to Medical Statistics* (Oxford: Oxford University Press), 1989.
14. Lonstein, J. E. and Winter, R. B.: The Milwaukee brace for the treatment of adolescent idiopathic scoliosis. Review of 1020 patients. *Journal of Bone Joint Surgery* [*America*], **76**: 1207–1221, 1994.
15. Noonan, K. J., Weinstein, S. L., Jacobson, W. C. *et al.*: Use of the Milwaukee brace for progressive idiopathic scoliosis. *Journal of Bone Joint Surgery* [*Britain*], **78**: 557–567, 1996.
16. Fernandez-Feliberti, R., Flynn, J., Ramirez, N. *et al.*: Effectivevess of TLSO bracing in the conservative treatment of idiopathic scoliosis. *Journal for Pediatric Orthopedics*, **15**: 176–181, 1995.
17. Mellerowicz, H., Böckel, T., Neff, G. and Frey, R.: Mittel- und Langzeitergebnisse der Behandlung von lumbalen Skoliosen mit dem Boston-Brace. Paper presented at the 42nd Annual Meeting of the Vereinigung Süddeutscher Orthopäden e.V., 28 April–1 May, Baden-Baden, Germany, 1994.
18. Thulbourne, T. and Gillespie, R.: The rib hump in idiopathic scoliosis. Measurement, analysis and response to treatment. *Journal of Bone Joint Surgery* [*Britain*], **58**: 64–71, 1976.
19. Bettany, J., Patridge, C. and Edgar, M.: Topographical, kinesiological and psychological factors in the surgical management of adolescent idiopathic scoliosis. In: M. D'Amico, A. Merolli and G. C. Santambrogio (editors) *The Threedimensional Analysis of Spinal Deformities* (Amsterdam: IOS Press), pp. 321–326, 1995.
20. Bettany, J., Edgar, M., Wojick, A., Irwin, A., Maclean, I. and Damato, M.: Are back shape changes following scoliosis surgery stable? A prospective three-year follow-up of five different surgical procedures. Paper presented at the European Spinal Deformities Society Meeting, 31 May–3 June, Birmingham, UK, 1994.
21. Collis, D. K. and Ponseti, I. V.: Long-term follow-up of patients with idiopathic scoliosis not treated surgically. *Journal of Bone Joint Surgery* [*America*], **51**: 425–445, 1969.
22. Pehrsson, K., Larsson, S., Oden A. *et al.*: Long-term follow-up of patients with untreated scoliosis. A study of mortality, causes of death, and symptoms. *Spine*, **17**: 1091–1096, 1992.
23. Bradford, D. S., Tay, B. and Hus, S.: Adult scoliosis: surgical indication; operative management, complications, and outcome. *Spine*, **24**: 2617–2629, 1999.
24. Weinstein, S. L.: Natural history. *Spine*, **24**: 2592–2600, 1999.
25. Daly, L. E. and Bourke, G. J.: *Interpretation and Uses of Medical Statistics*, 5th edn (London: Blackwell Science), pp. 73–74, 2000.