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REVIEW ARTICLE

# Review of metastatic spine tumour classification and indications for surgery: the consensus statement of the Global Spine Tumour Study Group

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**Abstract** Choosing the right operation for metastatic spinal tumours is often difficult, and depends on many factors, including life expectancy and the balance of the risk of surgery against the likelihood of improving quality of life. Several prognostic scores have been devised to help the clinician decide the most appropriate course of action, but there still remains controversy over how to choose the best option; more often the decision is influenced by habit, belief and subjective experience. The purpose of this article is to review the present systems available for classifying spinal metastases, how these classifications can be used to help surgical planning, discuss surgical outcomes, and make suggestions for future research. It is important for spinal surgeons to reach a consensus regarding the classification of spinal metastases and surgical strategies. The authors of this article constitute the Global Spine Tumour Study Group: an international group of spinal surgeons who are dedicated to studying the techniques and outcomes of surgery for spinal tumours, to build on the existing evidence base for the surgical treatment of spinal tumours.

**Keywords** Spine · Tumour · Metastasis · Classification · Surgery · Outcome · GSTSG

On behalf of the Global Spine Tumour Study Group.

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## Introduction

The spine is the commonest site for bone metastases, and the incidence of spinal metastases is increasing [1] and this is not surprising, with increasingly older populations, longer life expectancy, and improvements in medical treatment [2]. As many as 70% of cancer patients have spinal metastases, and up to 10% of cancer patients develop metastatic cord compression [3]. The commonest tumours that involve the spine are breast, lung, renal, prostate, thyroid, melanoma, myeloma, lymphoma and colorectal cancer [3, 4]. With improvements in chemotherapy, radiotherapy and hormonal therapies, survival times have increased over the years [5] and perhaps patients' expectations also. Surgical techniques have also improved, which, together with advances in technology, now allow the surgeon to treat spinal metastases more effectively than before [6, 7].

The role of surgery for metastatic spinal tumours is again under the spot light: surgery can improve mechanical stability, cord compression, and pain, but what role does surgery play in extending life expectancy [4, 7–10]? Older techniques of decompression without stabilisation have resulted in a worse outcome, and this has misled many in the past to believe that radiotherapy is the preferred option to surgery [11–14]. More recent evidence has shown that modern surgery (including anterior and posterolateral approaches with stabilisation) does in fact result in a better outcome than radiotherapy alone, and that quality of life after surgery is often improved [4, 12, 15–17]. However, when deciding to operate, we must remember that most patients with metastatic spinal tumours have a life expectancy which is governed by the tumour type and staging, and is usually <1–2 years. Therefore, surgery must not detract from the remaining quality of life. The complication rate for surgery can be as high as 20–30%, and this must be weighed against the intended benefits [18–20]. This applies especially to the more extensive en bloc resections which are associated with increased complexity and morbidity when compared with simpler palliative debulking procedures [6, 7, 10, 21]. Although it is now accepted that surgery is commonly the preferred treatment for spinal metastases, more evidence is needed to define the role and indications of the various surgical techniques and new treatments available.

Generally, it is accepted that surgery might be considered when a patient has a life expectancy of more than 3 months [22]. This estimation is often made typically by oncologists, but it is the surgeon who more fully appreciates the potential risks and benefits of surgical options and, therefore, it is important for surgeons to understand how prognostic factors influence quality and duration of life. The purpose of this article is to review the present systems available for classifying spinal metastases, how these classifications can be used to help surgical planning, discuss surgical outcomes, and make suggestions for future research. It is important for spinal surgeons to use the same classification systems for the techniques of surgery, staging of tumours, and outcome, to reach meaningful comparisons between published series. The authors of this article constitute the Global Spine Tumour Study Group (GSTSG): an international group of spinal surgeons who are dedicated to studying the outcomes of surgery for spinal tumours [21]. The group is collecting data to answer specific questions which are further discussed below.

## Classification of metastatic spinal tumours

Staging is mandatory and is often performed by oncologists unless surgery is urgent, for example, in patients with rapidly deteriorating neurological function. However, several surgeons have described methods of defining the extent of spinal involvement specifically to aid surgical planning and management. Some of these systems are based on the overall tumour load and functional status of the patient, whilst others focus on the anatomical extent of tumour involvement.

### Scoring and classification systems

Surgeons need to be aware of the patient's overall tumour load, life expectancy, quality of life, and other treatment options available, before deciding how 'aggressive' one should be with surgery. There will always be an element of risk when choosing to operate: if a complication occurs, this can quickly negate any intended benefit for a patient's quality of life.

Several classification systems for surgical staging have been described in an attempt to inform surgical strategies [7, 10, 23]. Tomita et al. studied the numerous major and minor prognostic factors for spinal tumours to describe a system based on three factors: the rate of growth of the primary tumour, number of bone metastases and visceral metastases [7] (Table 1).

The scores of these three components were added together to produce a total score in the range 2–10 (from good to poor prognosis, respectively). This system was constructed from retrospective data of 67 patients between 1987 and 1991, and the prognostic factors were given weighted scores after assessment of their statistical hazard ratios. The histology of the primary tumour correlates well with survival in both surgical patients [7, 10, 24, 25] and medical cohorts [25–28], with longer survival times seen in patients with myeloma, breast, prostate and thyroid cancers. The primary tumour type was, therefore, given more weight in the scoring system of Tomita et al. [7].

However, Tokuhashi et al. described a scoring system based on six parameters, which they later revised to take account of the stronger influence of primary tumour type on survival [10, 23]. The system comprised individual scores for the primary site of cancer, presence or absence of paralysis, Karnofsky's performance status, number of extraspinal bone metastases, vertebral body metastases and visceral metastases, producing a total score in the range 0–15 (from poor to good prognosis). Because the most important factor governing prognosis is the primary tumour type, the score gave more weight to the less aggressive tumours: five points for thyroid, breast prostate and carcinoid tumours; through to 0 points for lung, osteosarcoma, stomach, bladder, oesophageal and pancreatic tumours

**Table 1** Tomita prognostic score [7]

| | Score 1 | Score 2 | Score 4 |
|---|---|---|---|
| Primary tumour | Slow growth | Moderate growth | Rapid growth |
| Visceral metastases | | Treatable | Untreatable |
| Bone metastases | Solitary | Multiple | |

For each category (primary tumour, visceral and bone metastases) a score of 1, 2 or 4 is allocated according to the table above; these scores are added to provide a total score up to a maximum of 10

**Table 2** Revised Tokuhashi prognostic score [10]

| | Score 0 | Score 1 | Score 2 | Score 3 | Score 4 | Score 5 |
|---|---|---|---|---|---|---|
| Karnofsky's performance (%) | 10–40 | 50–70 | 80–100 | | | |
| Extraspinal bone metastases | 3 or more | 1–2 | 0 | | | |
| Vertebral metastases | 3 or more | 2 | 1 | | | |
| Visceral metastases | Unremovable | Removable | None | | | |
| Primary site (e.g.) | Lung | Liver | Other | Kidney | Rectum | Breast |
| Palsy | Frankel A, B | Frankel C, D | Frankel E | | | |

Scores for the six individual criteria above are added to provide a total score up to a maximum of 15

(Table 2). In the original paper of Tokuhashi et al. [23], it was interesting to note that there was no significant difference between survival times of different prognostic factors when analysed individually, whereas when grouped together to produce the score a significant difference became apparent. This suggests that for each prognostic factor the variation in survival is so large that one should not make judgements based on a single factor alone, for example, the primary tumour type, without taking into account the status of the whole patient. In their later paper [10], increasing the number of patients (and therefore the ability to detect smaller differences between groups) produced some statistically significant differences within individual categories, but of the six criteria evaluated no single group was able to demonstrate a consistent difference in survival.

It is interesting to note that Tokuhashi et al. found that paralysis was a prognostic factor in metastatic disease, whereas other studies of metastatic spinal cord compression and neurological symptoms did not show a direct correlation between neurological deficit and survival [29, 30]. It is, therefore, possible that paralysis is associated with an increased tumour load or rapid tumour growth, rather than being directly or independently related to poor survival. The significant influence of primary tumour type, neurological status and number of vertebral metastases was corroborated by other groups [29, 31, 32]. However, Enkaoua et al. found that patients with metastases from an unknown primary tumour had a worse prognosis than those with the identifiable tumours, unlike Tokuhashi's original description, which was later revised [10, 23, 29]. Zou et al. found that the Tokuhashi score was better for predicting short-term survival, whereas the Tomita score was more useful for predictions of long-term survival [33].

The GSTSG recommend the use of the Tomita and Tokuhashi staging systems, which are relatively straightforward to use and interpret. However, assessing the validity of these scores has previously been confounded by the choice of operation; for example, patients with good prognostic scores have received en bloc resections, whereas poor prognostic groups have received palliative treatment, and, therefore, it is difficult to say to what extent survival is influenced by the prognostic score or the surgery itself. By collecting a large amount of prospective data, the GSTSG intend to analyse survival times in different prognostic groups, matched by operation, to eliminate bias and rigorously validate these scoring systems.

Other classification systems have been described by North et al. and Harrington [9, 34]. North et al. retrospectively, studied 61 patients and found that risk factors for the ability to walk include non-breast metastases, the inability to walk before surgery, and operations other than corpectomy [9]. They also found that risk factors for decreased survival include non-breast metastases, recurrence after primary radiotherapy, multilevel surgery, and cervical location of tumour. Harrington used a simpler 5-point classification system which was based on the degree of spinal instability and neurological compromise [34] (Table 3). He felt that surgery was indicated only in the presence of spinal instability or mechanical pain, and perhaps over-emphasised the advantages of radiotherapy over surgery, which has been clarified by more recent evidence of the benefits of surgical intervention [15]. The Harrington classification is perhaps an over-simplification, resulting in quite broad categories of patients who may have very different prognoses. For example, a patient with nerve root pain, but good function may be allocated into the same group as a patient with complete paralysis from a large tumour.

**Table 3** Harrington classification of spinal metastases [34]

| | |
|---|---|
| 1 | No neurological involvement |
| 2 | Bone involvement without collapse or instability |
| 3 | Significant neurological impairment without bone involvement |
| 4 | Vertebral collapse with pain or instability, but no neurological impairment |
| 5 | Vertebral collapse with pain or instability and neurological impairment |

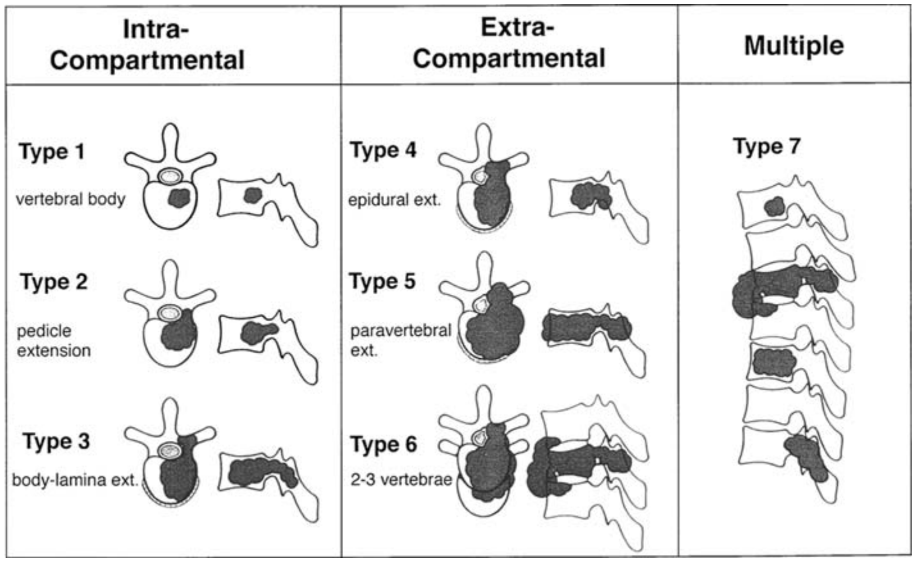


**Fig. 1** Schematic diagram of the surgical classification of spinal tumours, from Tomita et al. [7] (with permission of Lippincott Williams and Wilkin)

## Anatomical classifications

Anatomical classification systems can be useful for surgical planning, but are perhaps more suitable for the assessment of primary tumours rather than metastases. In general, to decide which type of operation to perform it is necessary to have more information than the anatomical context of the tumour alone. Tomita et al. devised a classification which comprises seven categories, depending on whether the metastasis is contained within the spinal bones (intracompartmental), out with the bones (extracompartmental), or multiple vertebral involvement (Fig. 1) [7]. This is a simple classification which is easy to remember and apply, and represents the natural stages of tumour progression from involvement of the vertebral body, to the pedicles and posterior elements, extradural and paravertebral spread, adjacent vertebrae and then multiple vertebrae. In practice, these stages do not necessarily occur in strict sequence, and usually types 4–7 are the levels of involvement which present to spinal surgeons.

Alternatively, McLain and Weinstein originally described the vertebral anatomy in terms of four zones and three concentric levels (Table 4) [35]. This scheme is very simple to use, but has the disadvantage that most spinal metastases would fall into the categories 3 and 4, resulting in a classification system that is not very discriminatory.

Enneking developed a classification system for primary long-bone tumours which has been adapted for use with spinal tumours. He described three stages of involvement of benign tumours, four stages for localised malignant tumours, and two further stages for metastatic high-grade tumours (Fig. 2) [36]. This system requires prior knowledge of the histology and degree of spread of the tumour throughout the body, which is not always available at the time of presentation. It may be applied to spinal tumours, but is not the most useful classification system, because it does not specifically document extradural spinal involvement and possible cord compression, and does not necessarily relate to prognosis.

**Table 4** McLain and Weinstein classification [35]

| | |
|---|---|
| Zone 1 | The spinous process to the pars and inferior facet |
| Zone 2 | The superior facet, transverse process and pedicle |
| Zone 3 | Anterior three-fourth of the vertebral body |
| Zone 4 | Posterior one-fourth of the vertebral body |
| Level A | Intraosseous |
| Level B | Extraosseous |
| Level C | Distant tumour spread |

The shortcomings of the classification systems of McLain and Weinstein [35], and Enneking [36], were partly addressed by Boriani et al. who developed a new staging system for primary bone tumours [37] (Fig. 3). They designed a system for the anatomical staging of primary bone tumours of the spine to overcome the drawbacks of these other systems. Although originally intended for use with primary tumours, the system of Boriani et al. has sometimes been applied to spinal metastases also [37]. This system was designed to aid surgical planning, because en bloc resection usually involves the removal of wedges or sections of the vertebra from around the spinal cord, which must not be violated. However, it is not as useful for planning of metastatic tumour surgery, since en bloc resection is not the goal in the majority of such cases.

Although this and other anatomical classifications are useful, there is not much data to suggest a correlation between the use of these systems and clinical outcome, unlike the surgical staging systems of Tomita et al. [7] and Tokuhashi et al. [10]. The WBB system, for example, is very accurate in describing the axial tumour involvement,

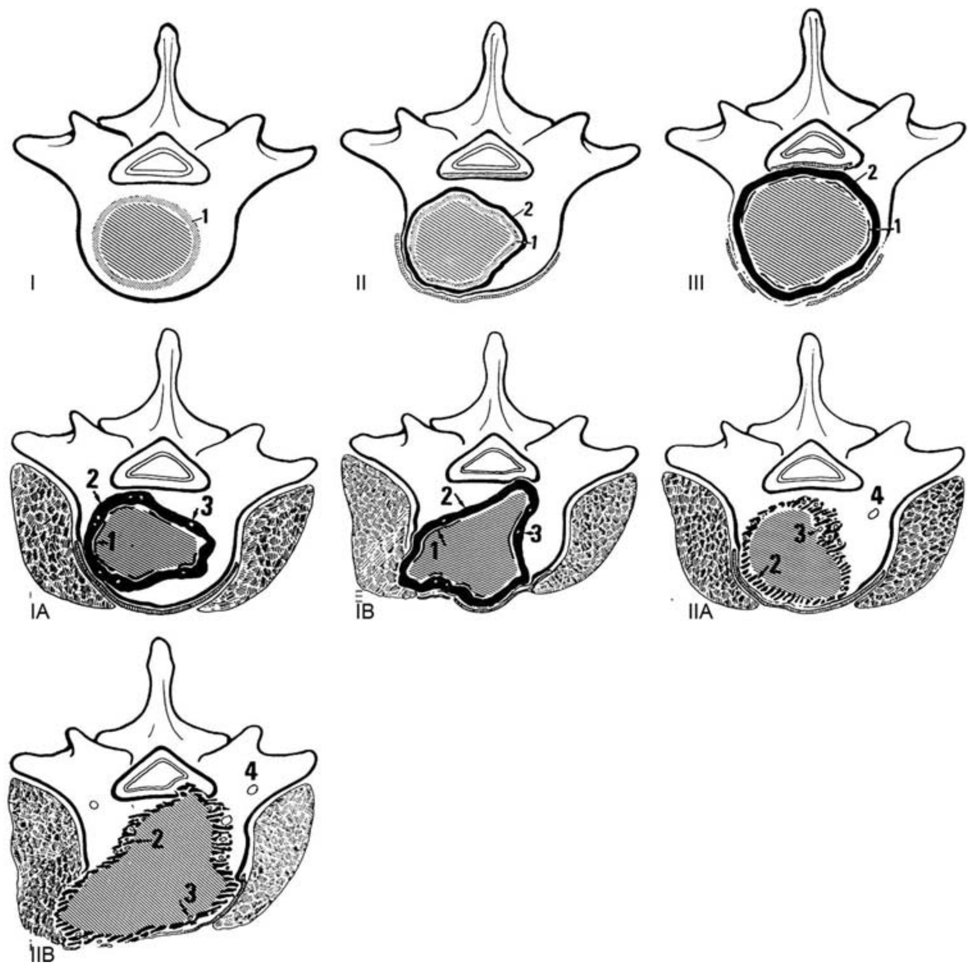


**Fig. 2** The Enneking classification of primary tumour staging. Benign tumours are classified as stages I, II and III, depending on the tumour growth and aggressiveness (*1* tumour capsule, *2* adjacent tissue reaction). Malignant tumours are classified as IA, IB, IIA and IIB depending on degree of spread (*1* tumour capsule, *2* tissue reaction, *3* island of tumour within adjacent tissue reaction, *4* skip metastasis) [36] (with permission of Lippincott Williams and Wilkin)

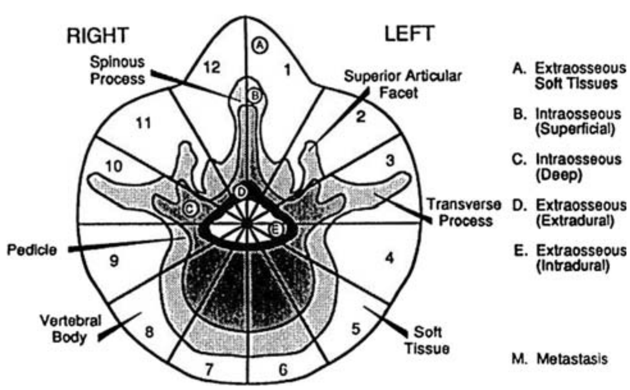


**Fig. 3** Weinstein, Boriani, Biagini (WBB) classification describes the vertebral involvement as sections of a clock face ("zones") centred on the spinal cord, from zone 1 (left spinous process and lamina) through zone 6 (left anterior wedge of vertebral body) and back round to zone 12 (right spinous process and lamina). In addition, the prefixes *A–E* are used to denote radial levels ("layers") of vertebral involvement, from extraosseous paraspinal tissues (*layer A*) through to extradural (*layer D*) and intradural (*layer E*) [37] (with permission of Lippincott Williams and Wilkin)

but the predictive relationship between WBB score and outcome is perhaps influenced more by the different types of surgery performed rather than the classification system itself.

## Prognostic classification and surgical planning

Tomita et al. recommended that patients with very good prognostic scores (2–3) should undergo wide excision, whereas patients with intermediate scores should undergo marginal or intralesional excision (scores 4–5), and palliative surgery (scores 6–7), whilst non-surgical supportive care should be performed for the worst prognostic group (scores 8–10) [7]. Evaluation of this scoring system was performed prospectively in 61 patients from 1993 to 1996, in whom the score was used to determine the type of operation to be performed, and length of survival was documented. The mean survival was 38.2 months in those patients with a good prognostic score who underwent en bloc resection, 21.5 months in those patients with intermediate score who underwent intralesional debulking procedures, and 10.1 months in those patients who underwent palliative decompression and stabilisation only. These results suggest that their recommendations are reasonable and practical.

Tokuhashi et al. recommended excisional surgery for patients with a good prognosis (Tokuhashi score of 12–15), palliative surgery for most patients with an intermediate prognosis (score of 9–11), and conservative management for patients with a score of 8 or less [10]. They prospectively applied their scoring system to 118 patients to help determine the surgical strategy and found a good correlation between the prognostic score and the actual survival ($r = 0.57$, significant $P < 0.0001$), with a consistency rate between predicted and actual survival of 86.4%. This suggests that the scoring system of Tokuhashi et al. is also a useful tool for the assessment of prognosis in patients for whom surgery is being considered.

## Recommendations of the GSTSG

Complications may occur in up to 25% of patients who undergo surgery for spinal metastases, the most common being wound infection [13, 17, 38]. Life expectancy is usually determined by the overall extent of the metastatic disease and, therefore, to be of benefit, surgery must improve quality of life. However, the incidence of complications increases with the complexity and extent of an operation, and, therefore, at some point there must be a trade-off between the benefits and risks of surgery [17]. Because surgery is palliative for the majority of patients with spinal metastases the assessment of overall quality of life is perhaps more relevant than physical scores and neurological outcome measures, and the GSTSG, therefore, advocates the use of quality of life measures for all patients undergoing surgery. Several studies have shown improvements in quality of life after surgery for metastases [4, 13, 39], with up to 80% of patients satisfied or very satisfied with the decision to operate [13, 39]. The greatest improvements are in the domains of pain, but also non-specific symptoms, such as tiredness, nausea, anxiety and appetite may improve after surgery [16]. The GSTSG uses the Euroquol EQ5D assessment tool for all patients with metastatic disease. This is a simple 5-point validated questionnaire that is simple for patients to complete and investigators to interpret [40].

Owing to the heterogeneity of patients who are referred to spinal surgeons, the outcome of surgery for spinal metastases is variable and it is, therefore, difficult to come to generalised conclusions regarding the ideal management [3]. The strong beliefs that surgeons often hold regarding the ideal management create difficulties in performing a randomised study of surgical techniques. The best alternative is to prospectively collect a large amount of data from which the effect of confounding variables can be removed by patient matching [41]. It is necessary to acquire this data over a relatively short time span of a few years, to avoid time bias which might result from changes in technique or instrumentation. The GSTSG aims to acquire such data from multiple centres in a timely fashion, to compare the outcomes of different treatment groups and assess statistically significant differences in management, by collecting data on a secure internet database (Fig. 4).

One specific example is to compare the outcome of total en bloc spondylectomy (TES) with simpler debulking procedures, which are probably associated with fewer complications [42]. It has been suggested that TES should be reserved for patients with solitary spinal metastasis with otherwise good prognosis to justify taking this extra risk [6, 22, 43]. However, the true difference in outcome between TES and debulking surgery in a specific group of patients is not known, but this may be determined by analysing our database to control for confounding variables and obtain a more accurate estimation of the usefulness of these procedures, and whether the extra risk is justified by improved survival and quality of life.

To collect data, it is important to be clear about how we define an operation, and to avoid using ambiguous terms which would invalidate the dataset. Boriani et al. stressed the importance of distinguishing between, and correctly using, the terms “radical, complete, extralesional and intralesional excision” [37]. The GSTSG has adopted a simple classification of surgical strategies, illustrated in Fig. 5, in which the excision of the involved vertebra is shown diagrammatically. The overall tactic of surgery may be for palliative decompression, tumour debulking, or total vertebrectomy (row 1, Fig. 5). The tactic chosen for a patient may then be achieved by piecemeal excision of tumour, or total vertebrectomy either by an en bloc or piecemeal method (row 2, Fig. 5). This method of excision will influence the tumour resection margins that may be intralesional, or wide/extralesional (row 3, Fig. 5). It is important for surgeons to be accurate and systematic in their description of surgical strategies and techniques, using a common surgical language, to allow meaningful comparisons of outcome. We present the first clear definitions for surgical methodology and strategy that may be applied to metastatic spinal tumours.

Other uses of the database include comparing the outcomes of different primary tumours, auditing complication rates, comparing surgical series to those of radiotherapy databases, and assessing quality of life. Presently, no published prognostic scoring system incorporates measures

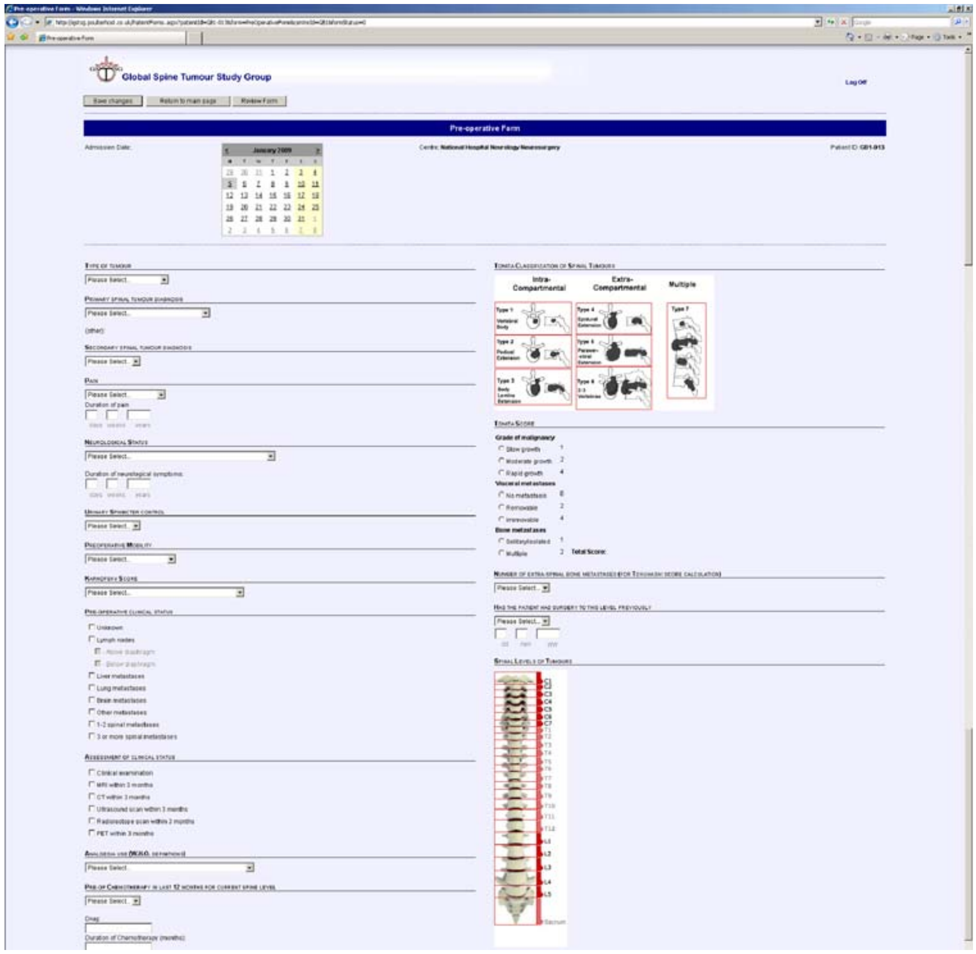


**Fig. 4** Page snapshot of the Global Spine Tumour Study Group prospective database for metastatic tumour surgery. Preoperative data entry

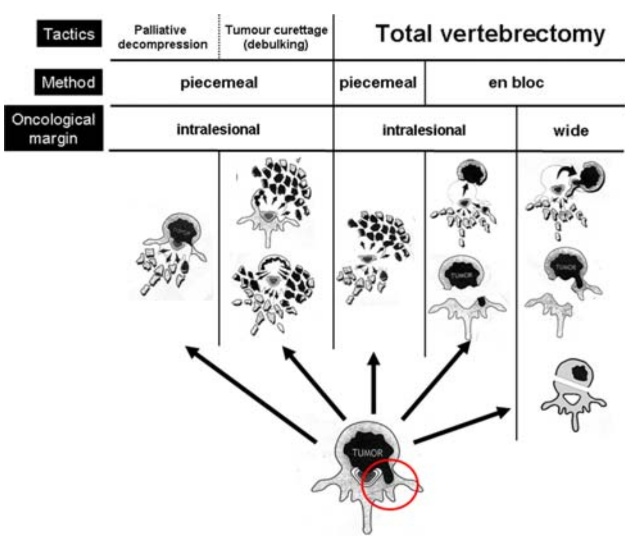


**Fig. 5** Classification of surgical strategies, as determined by the Global Spine Tumour Study Group

of quality of life beyond the Karnofsky's score, and it may be important to incorporate these measures in future scores [44].

It is often difficult to acquire reliable evidence for the validity of surgical treatments. Unlike clinical drug trials, it is impossible or unethical to blind the surgeon and patient in a study of surgical treatments. Follow-up can also be more difficult when patients live long distances away, and loss to follow-up may be more common. However, as far as possible, it is still important to ensure that clinical practice of surgeons is influenced by a strong evidence base. Hosono et al. studied a large retrospective series of patients with spinal metastasis, and concluded "a large prospectively designed study of consecutive patients is essential to screen the possible prognostic factors in patients with spinal metastases" [25]: a viewpoint which we strongly advocate.

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# Low back pain (non-specific)

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Low back pain (LBP) is defined as pain localised between the 12th rib and the inferior gluteal folds, with or without leg pain. Most cases are non-specific, but in about 10% of cases a specific cause is identified. Red flags are typical signs or symptoms that are frequently associated with specific LBP. Yellow flags are prognostic factors associated with a more unfavourable and often chronic disabling course of the disease. LBP has a lifetime prevalence of 60–85%. At any one time, about 15% of adults have LBP. LBP poses an economic burden to society, mainly in terms of the large number of work days lost (indirect costs) and less so by direct treatment costs. A substantial proportion of individuals with chronic LBP has been found to have chronic widespread pain. LBP is often associated with other pain manifestations such as headache, abdominal pain and pain in different locations of the extremities. Widespread pain is associated with a worse prognosis compared to localised LBP.

Treatment targets are reduction of pain and better activity/participation, including prevention of disability as well as maintainance of work capacity. The evidence from selected and appraised guidelines, systematic reviews and major clinical studies was classified into four levels, level Ia being the best level with evidence from meta-analysis of randomised controlled trials.

Key recommendations (level Ia): fitness programmes and advice to stay active can reduce pain, improve function and can prevent LBP becoming chronic. Simple analgesics, NSAIDs and muscle relaxants can reduce pain and can improve and maintain function. Maintaining physical activity, avoiding rest and manual therapy can reduce pain and maintain and restore function in acute LBP. Behavioural treatment can prevent LBP becoming chronic. Aerobic fitness and

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endurance training, behavioural treatment and multi-disciplinary treatment programmes can reduce pain and can improve/maintain function in chronic LBP.

**Key words:** low back pain; non-specific; treatment; guidelines.

## INTRODUCTION

*Low back pain* (LBP) is defined as pain localised between the 12th rib and the inferior gluteal folds, with or without leg pain. Most cases are non-specific, but in 5—10% of cases a specific cause is identified. *Specific* causes of back pain are some degenerative conditions, inflammatory conditions, infective and neoplastic causes, metabolic bone disease, referred pain, psychogenic pain, trauma and congenital disorders. *Non-specific* LBP is defined as back pain with no known underlying pathology. The term 'specific low back pain' is restricted by some health care professionals to destructive diseases such as tumour and infection, as well as to diseases associated with a neurological deficit, such as disc herniation and spinal stenosis. Others use this term in the presence of a localised source of pain when a specific structure of the spine is painful and if a specific diagnosis is available to characterise the cause of the pain. *Acute* LBP occurs suddenly after a period of a minimum of 6 months without LBP and lasts for less than 6 weeks. *Subacute* LBP occurs suddenly after a period of a minimum of 6 months without LBP and lasts for between 6 weeks and 3 months. *Chronic* LBP has a duration of more than 3 months, or occurs episodically within a 6-month period.

Considering the high prevalence of non-specific LBP, the *normal population* (i.e. the whole population at all ages) is the *population at risk*, because almost everyone has episodes of 'back pain'. Acute and subacute back pain is an *early* manifestation of the *disease*, whereas chronic LBP with high disability characterizes *late disease*.

> *Red flags* are typical signs or symptoms that are frequently associated with specific LBP (Table 1). *Yellow flags* are prognostic factors associated with a more unfavourable and often chronically disabling course of the disease (Table 2).

**Table 1.** Signs and symptoms with a high probability of being associated with specific causes of low back pain.

| Red flags | | | |
|---|---|---|---|
| Age | History | Symptoms | Findings |
| Presentation under 20 years | Violent trauma | Constant, progressive, non-mechanical pain | Persisting severe restriction of lumbar flexion |
| Onset over 55 years | Past history of cancer<br>Systemic steroids<br>Drug abuse<br>HIV | Neurological symptoms<br>Systemically unwell<br>Weight loss<br>Thoracic pain | Neurological signs<br>Structural deformity |

Source: Signs and symptom compiled according to Hutchinson et al (1999)[16], with slightly modified categories.

**Table 2.** Risk factors for occurrence and chronicity of non-specific low back pain.

| | Yellow flags | |
|---|---|---|
| | Occurrence | Chronicity |
| Individual factors | Age<br>Physical fitness<br>Strength of back and abdominal muscles<br>Smoking | Obesity<br>Low educational level<br>High levels of pain and disability |
| Psychosocial factors | Stress<br>Anxiety<br>Mood/emotions<br>Cognitive functioning<br>Pain behaviour | Distress<br>Depressive mood<br>Somatisation |
| Occupational factors | Manual handling of materials<br>Bending and twisting | Job dissatisfaction<br>Unavailability of light duty on return to work |
| | Whole-body vibration | Job requirement of lifting for 3/4 of the day |
| | Job dissatisfaction<br>Monotonous tasks<br>Work relations/social support<br>Control | |

Source: van Tulder (2002).[10]

## SIZE OF THE PROBLEM

### The perspective of the individual

LBP has a lifetime prevalence of 60–85%. At any one time, about 15% (12–30%) of adults have LBP.[1–3] The prevalence in most studies was determined regardless of the diagnosis or cause, which makes it difficult to make accurate assessments of the incidence of specific or non-specific LBP. One study reported that of all back pain patients in primary care, 4% had a compression fracture, 3% spondylolisthesis, 0.7% a tumour or metastasis, 0.3% spondylitis ankylopoetica and 0.01% an infection.[4]

Most episodes of LBP settle after a couple of weeks and most individuals will return to work within 1 week, with 90% returning within 2 months. With increasing duration of pain and disability the outcome gets worse. After 6 months sick leave, fewer than 50% will return to work and after 2 years of absence, there is little chance of returning to work at all.[5] Many LBP patients have a recurrent course with further acute episodes affecting 20–44% of patients within 1 year in the working population and lifetime recurrences of up to 85%.[6]

In population studies, a substantial proportion of individuals with chronic LBP has been found to have chronic widespread pain.[7,8] LBP is often associated with other pain manifestations such as headache, abdominal pain and pain in different locations of the extremities. Widespread pain is associated with a worse prognosis compared with localised LBP.[9] It has been suggested that the large proportion of individuals with LBP as part of a more widespread pain syndrome may be responsible for the major burden that chronic non-specific LBP has on both individuals and society.[10]

The impact of LBP on the individual can be evaluated within the framework of the WHO International Classification of Functioning, Disability and Health (ICF).[11] Non-specific LBP does not induce structural changes by definition, but can cause loss of health status in the form of symptoms and loss of function, limitation of activities and restricted participation. Loss of function relates to pain in the back and associated distress and behavioural problems. Limited activities include those of daily living, leisure activities and strenuous activities. There may be temporary or permanent work disability, chronic pain behaviour and dependence/care needs from others. Fear of the recurrence of back pain may also limit activities and restrict participation.

### The perspective of Society

LBP poses an economic burden to society, mainly in terms of the large number of work days lost (indirect costs) and less so by direct treatment costs. A cost-of-illness study of LBP in the UK estimated that the 1998 direct costs were £1.6 billion and that the overall costs varied between £6.6 billion and £12.3 billion depending on the costing method used.[12] The proportion of indirect costs depended on the health system and was found to be higher than the direct costs in Sweden (costs per capita: 24 US$ direct costs versus 266 US$ indirect costs, 8% versus 92%) and the Netherlands (24 US$ direct versus 299 US$ indirect, 7% versus 93%).[13] In the USA an analysis of 30,074 people in the 1988 Health Interview Survey showed that LBP was estimated to account for 149 million lost work days annually, while work-related LBP was estimated to cause the loss of 101.8 million work days. The annual costs of lost work time associated with chronic LBP were estimated to amount to $1230 for men and $773 for women, based on data from the 1987 USA National Medical Care Expenditure Survey. This translated into annual productivity losses of $28 billion.

A small percentage of patients with chronic LBP account for the largest percentage of costs as they have symptoms for more than 3 months. One study in the USA showed that only 4.6–8.8% of LBP cases lasted for more than 1 year but they accounted for 64.2–84.7% of the costs.[14]

## TREATMENT GOALS

In order to assess the evidence and develop recommendations key outcome measures were defined. These were defined according to the ICF classification[11]:

- Symptoms: pain
- Tissue damage/structure: the definition of non-specific back pain excludes the presence of tissue damage of relevance to the problem.
- Activity/participation:
    - Disability
        - Instruments specific to back pain: Roland Morris, Oswestry
        - Generic instruments: SF36, NHP, EuroQol
    - Return to work

According to these key outcome measures, targets can be defined that are most important in the prevention or management of back pain:

- Reduction of pain
- Better activity/participation
    - Prevention of disability
    - Maintainance of work capacity.

## WHAT CAN BE DONE: THE EVIDENCE FOR INTERVENTIONS TO PREVENT AND TREAT LOW BACK PAIN

The evidence for different interventions is considered below in the context of the agreed targets for the prevention and treatment of LBP and for the populations that the evidence applies to. However, only the effect on symptoms and activity/participation was considered. The effect on tissue damage was not considered because it is excluded, by definition, in non-specific LBP. The evidence is presented in Tables 3, 4 and 5, below. The evidence for these recommendations was taken from selected and appraised guidelines, systematic reviews and major clinical studies (see Sources of data used to support recommendations, below).

The evidence was classified into four levels[15]:

Ia: Evidence from meta-analysis of randomised controlled trials.
Ib: Evidence from at least one randomised controlled trial.
IIa: Evidence from at least one controlled study without randomisation.
IIb: Evidence from at least one other type of quasi-experimental study.
III: Evidence from descriptive studies, i.e. comparative studies, correlation studies and case–control studies.
IV: Evidence from expert committee reports or opinion, or clinical experience of respective authority or both.

The nature of the effect was classified as follows:

+, positive
0, evidence of no effect
−, negative effect
#, inconsistent findings
IE, inadequate evidence from which to make a grading

The grading of the recommendations was carried out as described by Eccles[15]:

A: Directly based on category I evidence.
B: Directly based on category II evidence or extrapolated from category I evidence.
C: Directly based on category III evidence or extrapolated from category II evidence.
D: Directly based on category IV evidence or extrapolated from category III evidence.

### Lifestyle Interventions

Various lifestyle factors increase the risk of developing non-specific LBP, increase the pain and influence the functional limitations associated with it. However, a number of factors have now been identified that may increase the risk of chronicity and long-term

**Table 3.** Efficacy of lifestyle interventions.

| Lifestyle interventions | | Aims of intervention | |
|---|---|---|---|
| | | Symptom | Activity and participation |
| Fitness programmes | At risk | Ia + | Ia + |
| | Acute | Ia + | Ia + |
| | Chronic | Ia + | Ia + |
| Education programmes (interactive) | At risk | IE | IE |
| | Acute | IE | IE |
| | Chronic | II+−III | Ia + |
| Advise to stay active (directive) | Acute | Ia + | Ia + |

The ICF category of function and structure is only represented by symptom. Tissue damage is not listed in this table, because it is excluded, by definition, in non-specific low back pain.

disability, but not one single factor seems to have a strong impact. The level of evidence from selected and appraised guidelines, systematic reviews and major clinical studies for lifestyle interventions on the target outcomes is summarised in Table 3.

Fitness programmes comprise exercises for flexibility, aerobics, co-ordination, muscular strength and endurance. Usually they are performed on a daily basis for at least 30 minutes. Examples are endurance training such as running, swimming, cycling or aerobic training.

Education programmes are aimed at explanatory downgrading to relieve fear. To be effective education programmes need to address patients' worries and involve simple measures to enhance physical activity together with ergonomic advice. Compliance is crucial for obtaining positive outcomes, but the evidence is unclear as to whether personal advice from a health professional is more effective than advice in the form of a pamphlet.

**Practice points**

*Effect on key outcomes*:

- Fitness programmes, education programs and advice to stay active can prevent back pain becoming a chronic condition (Level Ia).
- Fitness programmes and advice to stay active can reduce pain (Level Ia).
- Fitness programmes, education programmes and advice to stay active can improve/maintain function (Level Ia).

*Recommendations: lifestyle interventions*

*To prevent non-specific LBP for the whole population* there is evidence to support the recommendation of physical activity (D).
*To prevent non-specific LBP for the 'at risk' population* there is evidence to support the recommendation of physical activity (A).
*To reduce the impact of non-specific LBP for those with the condition* there is evidence to recommend physical activity (A) and education programmes (A), which have a positive impact on maintaining and restoring activity and participation.

*For all population definitions* the recommended lifestyle interventions for LBP are to stay physically active as far as possible (A) and to undertake moderate exercises several times per week.

## Pharmacological interventions

Non-specific LBP is characterised by pain, muscle tension or stiffness. These result in functional limitations. Drug therapies can control pain and may reduce muscle tension. Table 4 summarises the level of evidence from selected and appraised guidelines, systematic reviews and major clinical studies for pharmacological interventions on the target outcomes.

Pain can be relieved by the use of simple analgesics such as paracetamol or anti-inflammatory analgesics. Antidepressants, such as amitriptyline, also have a proven role in pain management for those with chronic LBP. Muscle relaxants, such as tetrazepam, can have a role in the management of LBP. Epidural injections of steroids are performed for LBP but the evidence does not support their recommendation for acute or chronic non-specific LBP.

### Practice points

*Effect on key outcomes*:

- Pharmacological treatment does not have any effect on the prevention of non-specific LBP or on preventing it from becoming chronic. Pharmacological treatment can reduce symptoms and improve function.
- Simple analgesics, non-steroidal anti-inflammatory drugs (NSAIDs) and muscle relaxants can reduce pain caused by non-specific LBP (Level Ia).
- Simple analgesics, NSAIDs and muscle relaxants can improve and maintain function (Level Ia).

**Table 4.** Efficacy of pharmacological interventions.

| Pharmacological interventions | | Aims of intervention | |
|---|---|---|---|
| | | Symptom | Activity and participation |
| Simple analgesics | Acute | Ia + | Ia + |
| | Chronic | Ia + | Ia + |
| Anti-inflammatory analgesics | Acute | Ia + | Ia + |
| | Chronic | Ia + | Ia + |
| Antidepressants | Chronic | Ia + | |
| Muscle relaxants[a] | Acute | Ia + | Ia + |
| Local treatment of epidural steroids | Acute | Ia 0 | Ia 0 |
| | Chronic | Ia 0 | Ia 0 |

[a] muscle relaxants are from the same substance group as diazepam (Valium) and, as such, share the same side effects e.g. drowsiness.

*Recommendations: pharmacological interventions*

*To reduce the impact of non-specific LBP for those with the condition* there is evidence to support the use of simple analgesics (A), NSAIDs (A) and muscle relaxants (A) for pain reduction.

## Rehabilitative interventions

Non-specific LBP is commonly associated with limited function that can be improved with a wide variety of rehabilitative interventions aimed at the whole person and not just at the painful area. Interventions will often be used as part of a multimodal programme, but the evidence presented relates to their effect as single interventions. In the presence of a localised source of pain, if a specific structure of the spine is painful and if a specific diagnosis is available to characterise the cause of pain, some rehabilitative interventions are of proven efficacy. However, there is not enough evidence to establish recommendations for which individual with LBP must be investigated by a therapist familiar with such techniques in order to recommend a more specific (=localised) therapy. It is the policy of this report to leave this question open and to give recommendations for the majority of patients in whom no localised and proven source of LBP was identified. Table 5 summarises the level of evidence from selected

**Table 5.** Efficacy of rehabilitation interventions.

| Rehabilitation interventions | | Aims of intervention | |
|---|---|---|---|
| | | Symptom | Activity and participation |
| Angular joint mobilisation | Acute | Ia # | Ia # |
| Joint play techniques | Acute | Ia + | Ia + |
| Traction | Acute | Ia 0 | Ia 0 |
| | Chronic | Ia 0 | Ia 0 |
| Rest | Acute | Ia − | Ia − |
| | Chronic | Ia − | Ia − |
| Functional immobilisation | At risk | Ia 0 | Ia 0 |
| | Acute | Ia 0 | Ia 0 |
| | Chronic | IE | IE |
| Strengthening exercises | Acute | Ia 0 | Ia 0 |
| | Chronic | Ia + | Ia 0 |
| Flexibility techniques | Acute | Ia 0 | Ia 0 |
| | Chronic | Ia 0 | Ia 0 |
| Biofeedback | Chronic | Ia 0 | Ia 0 |
| Relaxation Techniques | Chronic | Ia + | Ia 0 |
| Acupuncture | Acute | Ia 0 | Ia 0 |
| | Chronic | Ia 0 | Ia 0 |
| Aerobic fitness and endurance | Chronic | Ia + | Ia + |
| Therapeutic cold | Acute | IIa + | |
| Hydrotherapy | Chronic | IIa + | IE |
| Massage | Chronic | Ia + | Ia + |
| TENS | Chronic | Ia 0 | Ia 0 |
| Behavioural treatment | Acute | IE | IE |
| | Chronic | Ia + | Ia + |
| Multi-disciplinary programs | Chronic | Ia + | Ia + |

and appraised guidelines, systematic reviews and major clinical studies for rehabilitative interventions on the target outcomes.

The rehabilitative interventions listed in Table 5 comprise:

1. Angular joint mobilisation:
   - Active range of motion (ROM)-exercise – active training aimed at increased joint ROM.
   - Assisted ROM-exercise – movements are guided in specific directions depending on the symptoms of the patient e.g. McKenzie exercises.
   - Passive ROM-exercise – comprises stretching of muscle and connective tissue structures while the muscle is relaxed.
2. Joint play techniques:
   - Mobilisation (gliding of joint surfaces) – manipulation or slower mobilisation techniques, provided by a specialised manual therapist (chiropractor, osteopath, naprapath, physiotherapist, physician) by the use of a precise, directed force or thrust aiming to increase mobility between specified vertebrae and their muscles.
3. Traction:
   - The spine is pulled in a longitudinal direction, sometimes with a component of lateral rotation, aiming to increase nerve root space and mobility.
4. Rest:
   - Comprises bed rest and advice to 'rest and be careful'.
5. Functional immobilisation:
   - Corsets/braces/lumbar supports – can be of material with different stiffness and serve as a reminder not to perform excessive movements.
6. Strengthening exercises:
   - Aiming to increase muscle performance such as muscle activation, endurance and strength. Usually back, thigh and abdominal muscles are the targets.
7. Flexibility techniques:
   - Flexibility training/stretching – aiming to decrease joint and muscle stiffness. To be effective the exercises need to be conducted at least once a day.
8. Biofeedback:
   - Is used as electrical impulses to the muscles in order to stimulate endorphin production and reduce pain (e.g. Transcutaneous Electrical Nerve Stimulation (TENS), see below), or as a tool for achieving appropriate muscle activation during muscle techniques training. This latter biofeedback can also be given by verbal or visual stimuli.
9. Relaxation techniques:
   - Progressive relaxation techniques – training to decrease tense muscle activity through practicing more and more complex situations, e.g. from lying supine in a silent environment to applying the techniques in situations where the muscles usually get tense and painful.
10. Acupuncture:
    - Very thin needles are applied for 25–30 min at a defined depth in specific acupuncture points in order to give impulses to stimulate endorphin production and reduce pain. Sometimes electrical impulses are applied through the needles in order to increase the effect.
11. Aerobic fitness and endurance:
    - Exercises aiming to improve lung function and muscle performance, such as ergometer-cycling. Pulse rate should exceed 120 beats/min for 3 min during intervals.

12. Therapeutic cold:
    - Decreases nerve conduction velocity. It is applied locally for 10–15 min.
13. Hydrotherapy:
    - Involves both locally applied heat and exercises in warm water.
14. Massage:
    - Involves general massage techniques and locally applied techniques over tender points (acupressure) or muscles.
15. Transcutaneous Electrical Nerve Stimulation (TENS):
    - Electrical impulses are applied through rubber plates on the skin over nerves and muscles using an apparatus where currency and frequency can be adjusted. It can be used for 20–30 min daily in order to stimulate endorphin production and reduce pain.
16. Behavioural treatment:
    - Cognitive behavioural therapy aims to identify and modify a person's understanding of their pain and disability using cognitive restructuring techniques (such as imagery and attention diversion) or by modifying maladaptive thoughts, feelings and beliefs. Operant behavioural treatments include positive reinforcement of healthy behaviours and consequent withdrawal of attention from pain behaviours, time contingent instead of pain contingent pain management, as well as spouse involvement, while undergoing a programme aimed at increasing exercise tolerance towards a preset goal. Respondent behavioural treatment aims to modify physiological responses directly (e.g. reducing muscle tension by explaining the relation between tension and pain and using relaxation techniques).
17. Multidisciplinary treatment programmes:
    - A comprehensive, multi-professional programme with a combination of treatments, education, strengthening exercises and aerobic and fitness training. Usually the programme is conducted during full or half days for at least 4 weeks, sometimes combined with work-related measures and/or cognitive behavioural treatment.

**Practice points**

*Effect on key outcomes*:

- Maintaining physical activity, avoiding rest and manual therapy can reduce pain and maintain and restore function in acute LBP (Level Ia).
- Behavioural treatment can prevent LBP becoming a chronic condition (Level Ia).
- Aerobic fitness and endurance training, behavioural treatment and multidisciplinary treatment programmes can reduce pain in chronic LBP (Level Ia).
- Aerobic fitness and endurance training, behavioural treatment and multidisciplinary treatment programmes can improve/maintain function in chronic LBP (Level Ia).

*Recommendations: Rehabilitative Interventions*

*To reduce the impact of acute non-specific LBP for those with the condition* by reducing pain and maintaining and restoring function, then avoiding rest, maintaining physical activity and manual therapy is recommended (A).

*To reduce the impact of chronic non-specific LBP for those with the condition* by reducing pain and by maintaining and restoring function there is evidence to support the role of aerobic fitness and endurance training (A), behavioural treatment (A) and multidisciplinary treatment programmes (A).

## WHAT STRATEGIES SHOULD BE USED TO FOR THE PREVENTION AND TREATMENT OF LOW BACK PAIN

### Prevention

The prevalence and incidence of LBP appears to be moderately increasing, with a greater increase in the functional consequences, especially work disability. Systems of social support may also affect the chronicity of the problem in some cases. This increase may also be influenced by the ageing of the population along with a high rate of obesity and a sedentary lifestyle. LBP will therefore continue to be a major problem for individuals and society. Prevention is therefore important and there is theoretically potential for reducing the problem, but there is a need for studies on the effect of different interventions for primary prevention (reducing occurrence) and secondary prevention (reducing chronicity).

All adults should be considered at risk. LBP is very common and it is not yet possible to identify those in the community at greater risk of developing LBP with sufficient sensitivity or specificity to make any recommendations. ‘Yellow flags’ for persistence or recurrence need to be looked for (Table 2). There should be a strategy to encourage the population to change its behaviour and beliefs about LBP and on the importance of undertaking moderate exercise several times per week. The expected health gain is a reduction in the severity and occurrence of LBP. The potential benefit would be great because of the high prevalence of LBP.

### Early disease

There should be a strategy to encourage the population to change its behaviour and beliefs about LBP and on the importance of maintaining physical activity and employment by those with acute or subacute LBP. On a background of public awareness, health care professionals should learn to follow the appropriate guidelines, which recommend staying active, avoiding bed rest, using paracetamol, NSAIDs or manual therapy and addressing ‘red’ and ‘yellow flags’. This will result in reduced pain, improved functioning and maintainance of employment. Effective management of acute and subacute non-specific LBP will reduce the enormous burden associated with the transfer of those with acute to chronic LBP. The benefit for those with acute or subacute non-specific LBP as well as society as a whole will be seen immediately with better pain management, and will be seen within a few years with changes in beliefs and behaviour.

### Chronic disease

Effective treatments for subacute and chronic non-specific LBP are exercise therapy, behavioural therapy including pain management, or a combination of these. Multidisciplinary programmes should be delivered for non-specific LBP if there is no improvement with exercise or behavioural therapy. It is, as yet, unclear what the optimal

**Table 6.** Key recommendations for the treatment of non-specific specific low back pain.

| Population | Recommendation |
|---|---|
| Normal and 'at risk' | Stay physically active and do moderate exercises several times a week<br>Address risk factors |
| Early stage | |
| Until 6 weeks (acute) | If you feel some back pain, this is normal. Stay active and avoid bed rest. Reduce pain by medication (paracetamol at first then, if it is not effective, NSAIDs) or manual therapy<br>Be aware of red and yellow flags and investigate as appropriate |
| After 6 weeks (subacute) | Thorough assessment. Look for red flags to exclude tumour, infection, rheumatoid disease, fracture and disorders with neurological deficit. Identify yellow flags. It is not routinely recommended to undertake imaging unless suspicious of red flags<br>Undertake behavioural therapy including reassurance, training and workplace contact. Attempt to get the person back to work |
| Late stage | Thorough investigation after 3 months<br>Start to address rehabilitation programmes |
| At more than 3 months | Undertake multi-professional rehabilitation programmes including workplace contacts and occupational training |

content of these programmes is. Rehabilitation should be undertaken with due consideration and involvement of the workplace. LBP of known cause (specific LBP) needs specific management. Following this strategy, a reduction in symptomatology and less limitation of activities is expected. Those out of work or whose work is restricted due to chronic LBP will benefit most and this will be seen from the first year of such a strategy.

## SUMMARY

Acute and subacute low back pain are common problems. Treatment includes the advice to stay active and the use of paracetamol or non-steroidal anti-inflammatory drugs. Checks should be made for indicators of severe organic diseases as well as for risk factors of chronification! Recommended treatment for chronic non-specific LBP is exercise therapy, behavioural therapy including pain management, or a combination of these (Table 6).

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**Practice points**

- Standardise examinations by the use of yellow and red flag questionnaires
- Make sure that the entire team is expressing the advice to stay active
- Identify the availability of multidisciplinary programmes for your patients

**Research agenda**

More research is needed

- To prove the hypothesis that physical activity can prevent non-specific low-back pain
- To analyse whether special sports are particularly capable of preventing non-specific low-back pain
- To understand how joint play techniques work and reduce pain
- To determine whether and which specific degenerative causes of low back pain exist.

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# Operative Therapie von idiopathischen Skoliosen und juvenilen Kyphosen

**Zusammenfassung**

Die Hauptindikation zur operativen Behandlung von idiopathischen Skoliosen und Scheuermann-Kyphosen ist die Kosmetik. Allerdings sind auch Schmerzen bei Skoliosepatienten häufiger zu finden, und bei hochgradigen Deformitäten eine Einschränkung der Lungenfunktion, besonders wenn schwere Skoliosen bereits im Alter von 5 Jahren bestanden („early onset"). Skoliosen unter 30° nehmen im Erwachsenenalter nicht zu, jene zwischen 50° und 75° werden in den 40 Jahren nach Wachstumsabschluss um durchschnittlich 25° zunehmen. Bei juvenilen Kyphosen ist die Progression im Erwachsenenalter nicht gut dokumentiert.

Ziel der operativen Behandlung ist es, die Progression zu stoppen, das Wachstum der Wirbelsäule zu lenken, oder eine Korrektur und Fusion zu erzielen durch Instrumentation und Knochentransplantate. Das wird erreicht durch die Korrekturprinzipien der Kompression, Distraktion, Derotation und Translation.

Die zur Korrektur angewandten Kräfte werden durch Verankerungsteile (Pedikelschrauben, Wirbelkörperschrauben, Haken, sublaminäre Drahtcerclagen) auf die Wirbelsäule übertragen. Je höher die Korrekturkräfte sind, desto höher ist die erreichte Korrektur, desto höher ist aber auch das Risiko der Fraktur und des Ausrisses von Implantaten. Durch Mobilisation kann die Steife reduziert werden, und es kann bei gleichen Kräften eine bessere Korrektur erzielt werden. Die besten Mobilisationstechniken sind die Bandscheibenexzision, die Entfernung der Wirbelgelenke und Techniken zur Mobilisation des Thorax.

**Schlüsselwörter**

Skoliose · Kyphose · Morbus Scheuermann · Operative Korrektur · Mobilisationstechniken

## Indikationsstellung

Idiopathische Skoliosen und juvenile Kyphosen sind in der bei weitem überwiegenden Mehrzahl der Fälle Erkrankungen, welche den Patienten kosmetisch beeinträchtigen. Schwere *Störungen der Lungenfunktion* treten bei hochgradigen Skoliosen ein, welche vor dem 5. Lebensjahr auftreten („early onset"). Bis zum Alter von 5 Jahren bildet sich das Lungenparenchym aus, eine Störung in diesem Alter führt irreversibel zu weniger Lungenvolumen. Diese Patienten versterben früher als der Bevölkerungsdurchschnitt an Erkrankungen wie Cor pulmonale oder Pneumonien [3]. Skoliosen, welche nach dem 5. Lebensjahr auftreten („late onset"), können mit einer mäßigen restriktiven Ventilationsstörungen einhergehen, welche jedoch erst über Cobb 90° ein Ausmaß erreichen, welches Beruf oder Alltagsleben stört.

Die meisten Patienten mit idiopathischen Skoliosen, welche sich operieren lassen, haben zum Zeitpunkt der Operation eine normale Lungenfunktion [27]. Allerdings zeigt eine Studie, dass Skoliosepatienten noch 25 Jahre nach der Behandlung eine bessere Atemfunktion haben als vor Therapie [21]. Über restriktive Ventilationsstörungen bei juvenilen Kyphosen (M. Scheuermann) ist wenig bekannt. Zumindest bei älteren Patienten verschlechtert eine Kyphose die Lungenfunktion [26]. Patienten mit Scheuermann-Kyphosen mit einem Scheitelwirbel Th8 und höher und einer Krümmung von mehr als 100° Cobb haben eine restriktive Lungenfunktionsstörung [19].

Bei idiopathischen Skoliosen wird kontrovers diskutiert, ob *Schmerzen* häufiger auftreten als in der Normalbevölkerung. In einer großen Studie wurde bei 2441 Kindern mit idiopathischer Skoliose eine Kreuzschmerzprävalenz von 23% gefunden [5]. Dies entspricht ungefähr der Prävalenz von Rückenschmerzen bei Kindern in Querschnittuntersuchungen. Patienten mit thorakolumbalen und lumbalen idiopathischen Skoliosen haben deutlich häufiger (Punktprävalenz 68% bei Skoliosen, 35% bei Kontrollen) und mehr (Schmerzskala 3,2 zu 1,9 bei möglichen Werten bis 10) Schmerzen als eine vergleichbare Kontrollgruppe [24]. Rotationsolisthesen der Lendenwirbelsäule entwickeln sich häufig bei Lumbalskoliosen. Diese sind eindeutig mit Schmerzen assoziiert [28]. Bei Skoliosepatienten wird auch ein erhöhtes Ausmaß an degenerativen Veränderungen der Lendenwirbelsäule gefunden, sowohl bei operierten als auch bei konservativ behandelten Patienten [7].

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## Operative treatment of idiopathic scoliosis and juvenile kyphosis

### Abstract

Indication for operative treatment of idiopathic scoliosis and juvenile kyphosis is mainly cosmetic. There is also a higher incidence of pain in scoliosis patients, and reduced pulmonary function in severe deformity, especially in severe deformities present at the age of 5 years (early onset). Scoliotic curves of less than 30° will not progress in adults, whereas curves of 50–75° will further progress a mean of 25° during 40 years. Progression in adults with juvenile kyphosis is not well documented.

Operative treatment aims to stop progression, to control spinal growth, or to perform correction and fusion by spinal instrumentation and bone grafts. These goals can be achieved either by an anterior, a posterior, or a combined approach. Correction principles are compression, distraction, derotation and translation.

The forces applied by correction are transferred by fixation devices (pedicle screws, anterior screws, hooks, sublaminar wires) to the spine. The higher correction forces are, the higher is the correction achieved, but also the risk of fracture and torn out implants. Mobilisation reduces rigidity and allows to achieve a better correction with equal forces. The best mobilisation techniques are disc excision, facet joint removal, and techniques to mobilise the thorax.

### Keywords

Scoliosis · Kyphosis · Scheuermann's disease · Fixation devices

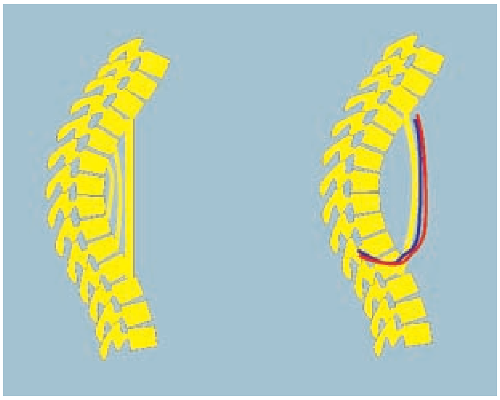

Abb. 1 ◀ ***Links:*** **Abstützspan mit autologer Fibula bei Kyphose. Der Raum zwischen Fibula und Wirbelsäule muss mit Knochenmaterial aufgefüllt werden, z. B. mit Rippenteilen, welche über den vorderen Zugang gewonnen wurden.** ***Rechts:*** **Abstützspan mit autologer, vaskularisierter Rippe, welche über den thorakalen Zugang gewonnen und aus dem Thorax in die abstützende Position gedreht wird**

Im Vergleich von 76 Scheuermann-Patienten (im Mittel 71°) mit 34 Kontrollpatienten wurden keine signifikanten Unterschiede bezüglich Krankenstandtage durch Kreuzschmerzen, Aktivitäten des täglichen Lebens, Selbstbewusstsein, Schmerzmedikamente und der Inzidenz von Spondylolisthesen gefunden [19]. Einige Patienten wiesen jedoch geringe neurologische Ausfälle auf.

Die *Progression* einer idiopathischen Skoliose im Kindesalter ist abhängig vom Krümmungsausmaß und der körperlichen Reife. Skoliosen unter 30° Cobb sind im Erwachsenenalter nicht progredient, Krümmungen zwischen 50° und 75° Cobb nehmen jedoch in den 40 auf den Wachstumsabschluss folgenden Jahren um weitere 25° Cobb zu [28, 29]. Krümmungen über Cobb 50° nach Wachstumsabschluss erreichen somit ein Ausmaß von ca. 75°. Für juvenile Kyphosen gibt es nur wenige Berichte und keine systematische Untersuchung über die Progredienz. In einem Bericht über 11 Fälle, die eine Korsettbehandlung nicht durchführten, war nur einer progredient. Allerdings bestehen Fallberichte über deutliche Krümmungszunahmen [30].

Von diesen Einschränkungen abgesehen bilden die meisten idiopathischen Adoleszentenskoliosen und juvenilen Kyphosen, wie eingangs festgehalten, ein kosmetisches Problem. Dieses ist jedoch häufig erheblich. Daher besteht verbreitet die Meinung, dass idiopathische Skoliosen über Cobb 50° operiert werden sollten. Bei Skoliosen zwischen 40° und 50° sollte in Abhängigkeit von der zu erwartenden Progression die Indikation zur Operation gestellt werden [12]. Zu ergänzen wäre, dass kosmetisch besonders ungünstige Skoliosen, z. B. bei sehr ausgeprägter Lordose, auch bei geringeren Cobb-Winkeln operiert werden sollten. Für Kyphosen ist es schwieriger eindeutige Empfehlungen zu geben. Juvenile Kyphosen über 70° Cobb stellen jedoch unseres Erachtens eine Operationsindikation dar, wenn lumbale Schmerzen vorliegen oder ein durch die kosmetische Beeinträchtigung bedingter Leidensdruck besteht.

In einer idealen Arzt-Patienten-Beziehung sollten die therapeutischen Ziele von Arzt und Patient möglichst übereinstimmen. Der Arzt kennt die Möglichkeiten und Grenzen der von ihm be-

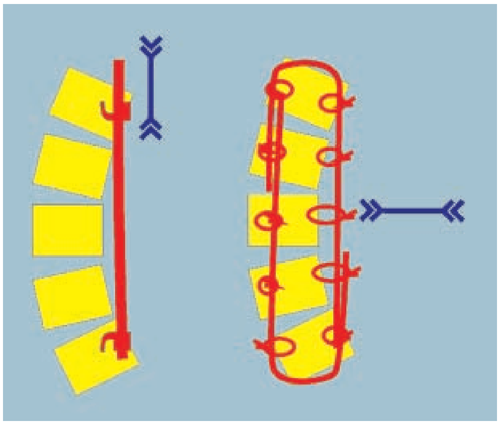

Abb. 2 ◀ ***Links:*** **Korrektur durch Instrumentation ohne (konkavseitige) Fusion mit subkutanem Harrington-Stab. Der Stab steht kranial über den Haken hinaus, um weitere Distraktionen ohne Stabwechsel zu ermöglichen.**
***Rechts:*** **Korrektur durch Luque trombone. Es werden 2 Stäbe posaunenartig so gebogen, dass sie teilweise überlappen und mit zunehmendem Körperwachstum auseinander gleiten. Die Korrektur erfolgt durch Translationskräfte, welche über sublaminäre Drahtcerclagen die Wirbelsäule an die Stäbe annähern**

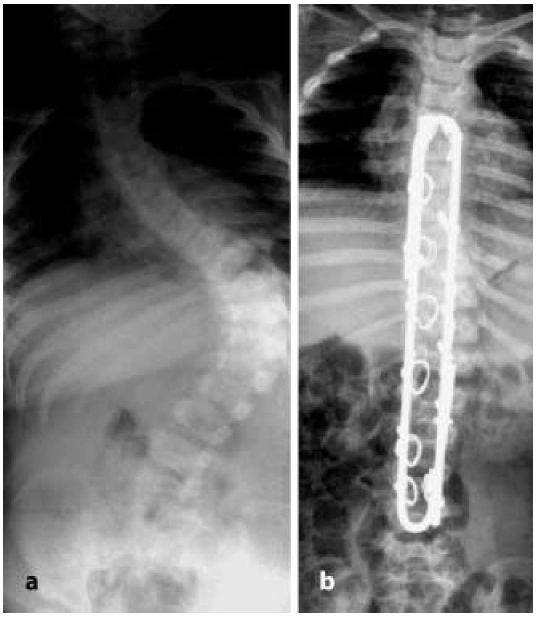


Abb. 3a, b ◀ **Röntenbild vor (a) und nach (b) Durchführung einer konvexseitigen Epiphysiodese und dorsalen Fusion sowie Instrumentation mit Luque trombone**

herrschten Therapien und muss dem Patienten zu realistischen Erwartungen verhelfen. Bei idiopathischen Adoleszentenskoliosen und juvenilen Kyphosen hat der Patient ein erhebliches kosmetisches Problem, welches operativ behandelt werden kann. Die Operation birgt Risiken bis hin zur Querschnittläsion. In dieser Situation sieht der Patient folgende Ziele einer Operation:

- Gutes kosmetisches Ergebnis, „unauffällig werden".
- Kein bleibender Schaden.
- Normales Leben so schnell wie möglich wieder aufnehmen (Beruf, Freizeit).
- Keine starken Schmerzen perioperativ.

An diesen Kriterien wird der Patient den behandelnden Arzt messen. Ärzte neigen dazu, mehr operationsbezogene Kriterien in den Vordergrund ihrer Berichte zu stellen wie Cobb-Winkel und Korrektur derselben, Dekompensation, Derotation, Blutverlust.

Die *kosmetische Zielsetzung* bedeutet, körperlich unauffällig zu werden. Rundrücken, Rippenbuckel, einseitiger Schulterhochstand, Taillenasymmetrie werden vom Patienten versteckt. Das Schwimmbad wird gemieden, die Kleidung unter der Zielsetzung ausgewählt, den körperlichen Makel zu verbergen. Ein Eingriff ist dann erfolgreich, wenn der eigene Körper wieder als herzeigbar und unauffällig angesehen wird.

Komplikationen werden vom Patienten in Kauf genommen, solange *kein bleibender Schaden* entsteht. Die Querschnittläsion oder die Leberzirrhose durch Hepatitis C als Folge eines operativen Wirbelsäuleneingriffs mit kosmetischer Indikationsstellung sind jedoch so schwerwiegend, dass Aspekten der Sicherheit Priorität eingeräumt werden muss.

Ein normales Leben soll rasch wieder aufgenommen werden. Postoperativ soll ein *Bewegungsumfang* vorliegen, der Alltagsbewegungen erlaubt. Durch die operative Versteifung langer Abschnitte der Brust- und Lendenwirbelsäule wird die Rumpfrotation (untere Brustwirbelsäule) und die Rumpfseitneigung (Lendenwirbelsäule) meist erheblich eingeschränkt. Glücklicherweise ist jedoch die Rumpfvorbeuge die wichtigste Alltagsbewegung, und eine Einschränkung dieser Bewegung in der Wirbelsäule kann meist durch die Hüften kompensiert werden. Der Patient erwartet, nach 2–3 Monaten Schule oder Beruf wieder aufnehmen zu können.

## Operationsverfahren

Operationen zur Behandlung idiopathischer Skoliosen und juveniler Kyphosen können drei unterschiedliche Ziele verfolgen [16]:

- Erhalten des Status quo (Progression verhindern),
- Wachstum lenken,
- Korrigieren und Korrektur halten.

Ein Erhalten des Status quo ohne angestrebte Korrektur ist nur dann erstrebenswert, wenn eine Korrektur ein erhebliches Risiko darstellt. Dies kann bei kongenitalen und iatrogenen Deformitäten sehr wohl der Fall sein. Im Zusammenhang mit idiopathischen Skoliosen ist diese Zielsetzung unerheblich, kann aber bei Kyphosen eine Rolle spielen.

### Erhalten des Status quo

Das Erhalten des Status quo ist dann indiziert, wenn eine progrediente Deformität nur mit erheblichem Risiko durch eine Operation korrigiert werden kann. Eine Risiko-Nutzen-Analyse, welche Gegenstand eines Gesprächs zwischen Arzt, Patient und Angehörigen ist, kann zum Ergebnis kommen, dass ein Stopp der Progredienz ohne wesentliche Korrektur erstrebenswerter ist als eine Korrektur mit hohem Risiko. Ein solches Vorgehen ist bei kongenitalen Deformitäten häufig sinnvoll, bei idiopathischen Skoliosen fast nie indiziert, und bei einer Scheuermann-Kyphose nur dann zu erwägen, wenn jene so hochgradig ist,

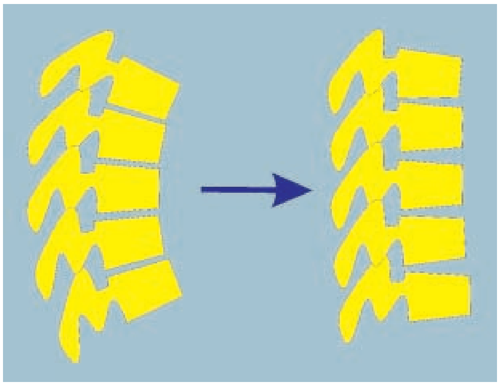

Abb. 4 ▶ **Die Form der Wirbelkörper bleibt bei der Korrektur unverändert, nur die Stellung der Wirbel zueinander wird verändert**


**Abb. 5 ▲ Schematische Zeichnung eines Skoliosewirbels der Brustwirbelsäule. Der Pedikel ist auf der Konvexseite kräftiger, das Wirbelgelenk auf der Konkavseite, die intrinsische Rotation ist gut erkennbar (aus: C. Nicoladoni (1882) Die Torsion der skoliotischen Wirbelsäule. Ferdinand Enke, Stuttgart)**

dass eine Aufrichtung wegen der bestehenden Verkürzung ventraler Strukturen wie Thorax, Bauchmuskulatur, innerer Organe nicht möglich ist. Die Abstützung kann durch eine autologe Fibula oder eine vaskulär gestielte Rippe erfolgen ([15]; Abb. 1).

Bei Patienten mit großem Wachstumspotenzial ist ein Abstützspan gefährlich. Erfolgt die gewünschte Fusion des Abstützspans mit der Wirbelsäule, und wächst die Wirbelsäule weiter, entsteht eine sehnenartige Struktur, welche die Wirbelsäule in eine zunehmende Kyphose zwingt.

## Wachstum lenken

Im Prinzip kann Wachstum gelenkt werden durch ventrale und dorsale Eingriffe, einseitig oder beidseitig, je nach zugrundeliegender Deformität. Bei einem einseitigen ventralen Eingriff wird ein Stück der Bandscheibe mit Apophyse entfernt und durch Knochenspäne ersetzt. Dies kann auch thorakoskopisch erfolgen [9, 25]. Bei einem dorsalen einseitigen Eingriff werden die Wirbelgelenke im zu behandelnden Abschnitt der Wirbelsäule teilweise reseziert und dann Knochenspäne angelagert. Bei kleinen Kindern wird Bankknochen verwendet.

Einzelne Publikationen berichten, dass bei kleinen Kindern mit infantilen Skoliosen eine kombinierte ventrale und dorsale konvexseitige operative Reduktion des Wachstumspotenzial zu einer langfristigen Korrektur oder zumindest zum Halten der Krümmung führt [1, 13]. Andere Publikationen zum Teil mit größerem Patientengut berichten, dass nur eine zusätzliche Korrektur durch Instrumentation ohne Fusion ausreichend effektiv ist [18, 23]. Wir empfehlen daher bei Skoliosen die Kombination von Instrumentation und konvexseitiger Fusion ventral und dorsal, wobei in begründeten Fällen (Kyphose oder Lordose) nur ventral oder nur dorsal fusioniert wird. Die Instrumentation kann durch Distraktion mit einem Stab-Haken-Konstrukt erfolgen, wobei durch Ausspreizen oder Nachdrehen von Muttern alle 4–6 Monate je nach Korrekturverlust eine erneute Distraktion erfolgt. Bei diesem Verfahren erfolgt alle 4–6 Monate eine Operation mit relativ kleinem Zugang (ca. 4 cm Inzision), ungefähr alle 2 Jahre wird ein Stabwechsel durchgeführt. Zur Vorbeugung einer Hakendislokation ist eine permanente Korsettversorgung nötig.

Alternativ, und unserer Meinung nach effektiver, ist eine Konstruktion mit Luque trolley oder Luque trombone (Abb. 2 und 3), bei der die häufigen Reoperationen zum Nachspannen entfallen. Hier kann ein Stab oder können 2 Stäbe, welche mit Drahtcerclagen fixiert sind, mit dem Längenwachstum der Wirbelsäule entlang der Wirbelsäule gleiten. Wichtig ist, bei der Präparation der Konkavseite dorsal die Wirbelsäule nicht zu denudieren, sondern im Gegensatz zur sonst üblichen Präparationstechnik die autochthone Muskulatur wirbelsäulennah zu durchtrennen. Dennoch kommt es nicht selten zu ungewünschten Fusionen. Bei Komplikationen stellt die Entfernung der Cerclagen ein Gefahrenpotenzial dar. Kürzlich wurde über eine größere Serie berichtet [23], bei der die Cobb-Winkel von durchschnittlich 65° nach 5 Jahren auf 35° reduziert und dann gehalten werden konnten.

## Korrigieren und Korrektur halten

Da das Grundprinzip der Korrektur einer deformierten Wirbelsäule abweicht von jenen Korrekturprinzipien, die bei langen Röhrenknochen zur Anwendung gelangen, ist ein Hinweis darauf an dieser Stelle nötig. Verfahren zur Veränderung der Wirbelform sind in Erprobung, aber nicht im klinischen Einsatz. Daher ist eine Voraussetzung aller derzeit üblichen Korrekturverfahren, dass die bei idiopathischen Skoliosen und juvenilen Kyphosen immer veränderte Wirbel-

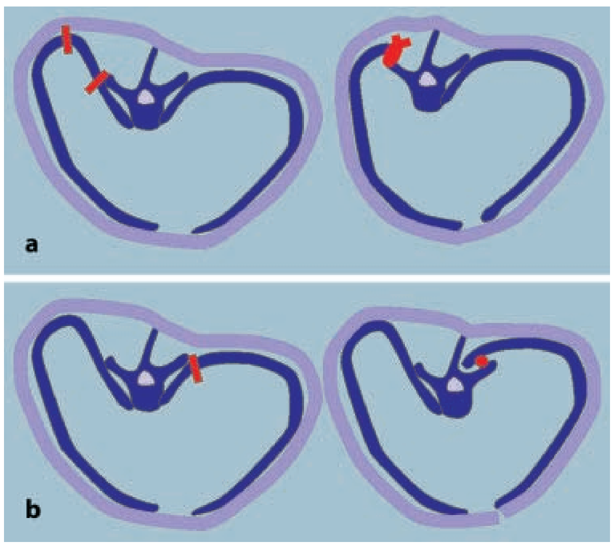


**Abb. 6a, b ▲ Technik zur Rippenbuckelresektion und zur Anhebung des Rippentals. a Bei der Rippenbuckelresektion wird der Rippenstumpf mit einem kräftigen, nicht resorbierbaren Faden mit dem Querfortsatz verknüpft. b Bei der Anhebung des Rippentals wird die Rippe über den implantierten Stab gehoben und auf diesem mit Naht befestigt. Die Rippe bekommt Anschluss an die zur Fusion angelegten Knochenspäne. Beide Verfahren helfen auch bei thorakalen Skoliosen den Thorax zu mobilisieren**

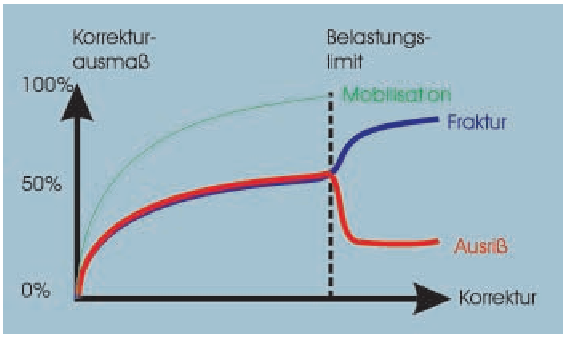


Abb. 7 ▲ **Die Abszisse zeigt die erzielte Korrektur. 100% bedeutet eine Wirbelsäule mit normaler Form, 0% die Ausgangssituation. Die Ordinate zeigt die zunehmend angewandte Kraft („load-displacement-curve"). Bei zu hoher Kraft tritt der Riss von Bändern, ein Ausriss von Haken oder Schrauben, bzw. eine Fraktur ein. Dadurch erfolgt eine sprunghafte Verlagerung**

form nicht korrigiert wird, sondern nur die Stellung der Wirbel zueinander (Abb. 4). Da die Stellung der Wirbel zueinander durch Bandscheiben, Bänder, Wirbelgelenke, Muskeln und Brustkorb gehalten wird, wird das Ausmaß der Korrektur davon abhängen, ob diese Strukturen im Rahmen der Korrektur nur in ihre Endlage bewegt oder aber operativ durchtrennt, reseziert, mobilisiert werden. Keilresektionsverfahren wie die „eggshell procedure" bilden eine Ausnahme, werden aber bei idiopathischen Skoliosen und juvenilen Kyphosen in den seltensten Fällen zur Anwendung kommen.

Die Deformität der Wirbelkörper kann erheblich sein. Juvenile Kyphosen sind definiert durch eine Keilform der Wirbelkörper, entweder 3 Wirbelkörper mit mindestens 5° Keilform, oder ein Wirbel mit mindestens 10°. Bei Skoliosewirbeln besteht eine starke intrinsische Rotation, welche auch von kranial nach kaudal bis zu 6° pro Wirbel zu oder abnehmen kann ([17]; Abb. 5).

## Mobilisationstechniken

Am effektivsten erfolgt eine Mobilisation über Entfernung von Bandscheiben. Juvenile Kyphosen sind oft recht flexibel. Zeigt jedoch eine Röntgenaufnahme der Brustwirbelsäule seitlich im Liegen bei Lagerung des Scheitelwirbels auf einer Rolle, dass keine wesentliche Korrektur erzielt wird, so kann durch Resektion der ventralen Bandscheibenanteile und Lig. longitudinale anterius eine sehr effektive Korrektur erreicht werden. Hochgradige Kyphosen sind allerdings auch durch die erworbene rigide Thoraxform schwer zu korrigieren. Bei Skoliosen können vordere Korrekturverfahren häufig eine ausgezeichnete Korrektur und sogar eine Überkorrektur erreichen, weil die Bandscheiben dort entfernt werden und somit eine effektive Mobilisation im Verfahren inkludiert ist.

Durch *Thorakoskopie* kann eine Mobilisation mit geringerer Invasivität erfolgen als bei offener Thorakotomie. Bei Skoliosen muss nur der konvexe Anteil des Diskus entfernt werden. Bei Skoliosen unter 70° ist dies selten nötig, bei Skoliosen über Cobb 90° liegt die Wirbelsäule so knapp unter der Brustwand, dass nicht genügend Raum für eine thorakoskopische Mobilisation zur Verfügung steht. In diesem Indikationsbereich ist das Verfahren effektiv und leicht durchführbar [20]. Bei juvenilen Kyphosen sind die Bandscheiben sehr schmal, der vordere Anteil des Diskus muss auch auf der dem Zugang abgewandten Seite entfernt werden. Hier erscheint uns ein offener Zugang zielführender.

Bei schweren thorakalen idiopathischen Skoliosen verhindert die Rigidität des Thorax häufig eine ausreichende Korrektur. Hier kann durch Durchtrennen der Rippen auf der Seite des Rippentals und Anheben des Thorax auf den zur Instrumentation verwendeten dorsalen konkaven Stab nach Beendigung der Korrektur eine Mobilisation erfolgen, ebenso durch Rippenbuckelresektion (Abb. 6). Allerdings sind derartige Eingriffe mit einer Reduktion der Vitalkapazität verknüpft und sollten bei grenzwertiger Atemfunktion nicht zur Anwendung kommen.

Das Korrekturausmaß ist abhängig von der Flexibilität der Krümmung und dem Ausmaß sowie der Richtung der angewandten korrigierenden Kräfte. Die korrigierenden Kräfte können nicht beliebig erhöht werden, da die Verbindung zwischen dem zur Korrektur verwendeten Instrumentarium und den Wirbeln nicht beliebige Kräfte verträgt. Somit kann zwar durch Wahl stabiler Verbindungen zwischen Instrumentarium und Wirbeln, wie dies vor allem auch Pedikelschrauben darstellen, das Ausmaß der angewandten Kraft erhöht und somit auch die Korrektur verbessert werden. Alternativ kann durch Mobilisation bei niedrigeren Kräften ebenfalls mehr Korrektur erzielt werden (Abb. 7).

## Korrekturmechanismen

Die Korrektur kann in dreierlei Richtung erfolgen. *Kompression* hat den Vorteil, dass zumindest bei idiopathischen Skoliosen und juvenilen Kyphosen keine Dehnung des Rückenmarks eintritt, das neurologische Risiko somit gering

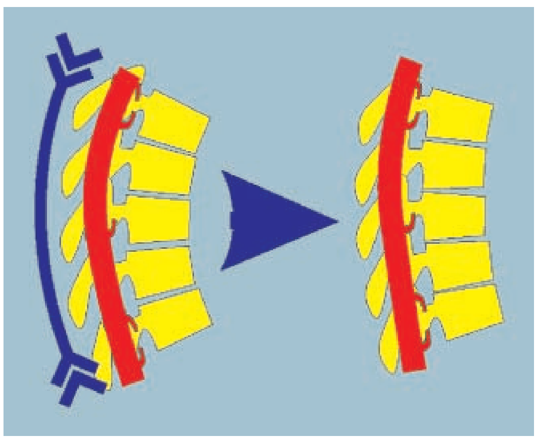

Abb. 8 ▶ **Durch Kompression eines dorsalen Instrumentariums erfolgt dorsal eine Verkürzung der Wirbelsäule und damit die Korrektur einer Kyphose**

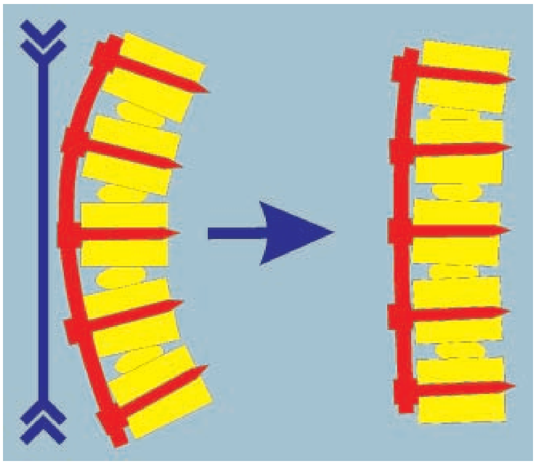

Abb. 9 ◀ **Über ein Hypomochlion wird von ventral komprimiert und dadurch die Skoliose korrigiert. Voraussetzung ist ein biegsamer Stab, der zunächst entsprechend der Skoliose gebogen ist, sich aber im Laufe der zunehmenden Kompression begradigt**

ist. Bei juvenilen Kyphosen ermöglicht die dorsale Kompression eine effektive Korrektur (Abb. 8). Ist die Krümmung sehr rigide, wird eine ventrale Mobilisation durch Entfernung der vorderen Anteile der Bandscheiben sinnvoll sein. Bei idiopathischen Skoliosen hat nur die Korrektur durch Kompression von ventral Bedeutung erlangt. Zwar stand bei Harrington-Instrumentarium ein Kompressionsinstrumentarium von dorsal zur Verfügung, die Hauptkorrektur erfolgte aber über Distraktion.

Die Kompression ist bei der ventralen Korrektur von Skoliosen ein wesentliches Korrekturprinzip, welches bei den Verfahren nach Dwyer [8] und Zielke [31] sowie den daraus abgeleiteten Verfahren zur Anwendung kommt. Mit der Korrektur der Seitkrümmung ist dabei immer auch eine Kyphosierung verbunden, was in der Lendenwirbelsäule nicht erwünscht ist. Durch Verwendung von ausreichend hohen Knochentransplantaten oder Implantaten kann dieser Effekt vermieden werden (Abb. 9). Neben der Kompression steht ventral noch der Korrekturmechanismus der Derotation zur Verfügung, auf den später eingegangen wird.

Die *Distraktion* war der erste Korrekturmechanismus, der bei der Instrumentation von Skoliosen zur Anwendung kam in Form der Haken-Stab-Instrumentation von Harrington [10]. Die Distraktion der Wirbelsäule ist mit einer Distraktion des Myelons vergesellschaftet, somit mit einem erhöhten neurologischen Risiko. Je geringer das Ausmaß der Krümmung, desto weniger effizient ist das Korrekturprinzip der Distraktion. Bei größeren Krümmungen nimmt die Effizienz deutlich zu. Das Prinzip der Distraktion wird auch bei Abstützspänen (Abb. 10) verwendet, wenngleich meist mit dem Ziel, im Sinne der Risikoverminderung nur so stark zu distrahieren, dass der Abstützspan sicher verankert bleibt.

Bei der dorsalen Instrumentation von Skoliosen sollte die Distraktion wegen des höheren neurologischen Risikos nicht zur Anwendung kommen. Als zusätzliches Korrekturprinzip ist die Distraktion jedoch weit verbreitet und sinnvoll.

Die *Derotation* wurde als Korrekturprinzip von Cotrel u. Dubousset ausschließlich für Skoliosen eingeführt [6]. Die Idee beruht auf der Beobachtung, dass bei idiopathischen Skoliosen der Brustwirbelsäule regelmäßig im Apexbereich eine Region mit verminderter Kyphose oder sogar Lordose (Hypokyphose) zu beobachten ist. Es bestand nun die Vorstellung, die Deformität in der Frontalebene, die skoliotische Seitneigung, in die Sagittalebene zu rotieren und somit eine erwünsche Kyphose zu schaffen (Abb. 11). Der Korrekturmechanismus ist genauso effizient wie jener der Translation. Krümmungen über Cobb 70° können schlecht versorgt werden, weil diese Krümmungen einerseits zu rigide sind, andererseits die an die Wirbelsäulenkrümmung angeglichene Biegung des Stabes zu stark ist, um sie in eine Kyphose der Brust- oder Lordose der Lendenwirbelsäule umzuwandeln.

Werden CT-Bilder prä- und postoperativ genau analysiert, so zeigt sich, dass keine echte Derotation eintritt in dem Sinn, dass der apikale Wirbel gegen die Endwirbel korrigierend verdreht wird, wohl aber eine komplexe Transla-

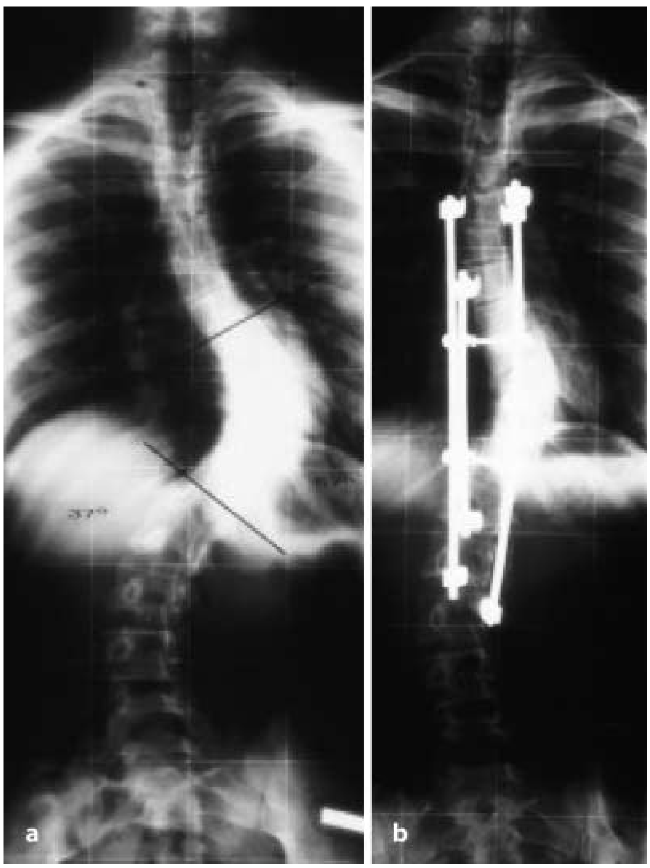


Abb. 10a, b ▶ **Korrektur einer Skoliose durch Distraktion, unter Verwendung von 2 distrahierenden Stäben, wobei allerdings durch die Annäherung der beiden Distraktionsstäbe auch das Prinzip der Translation zur Anwendung kam**

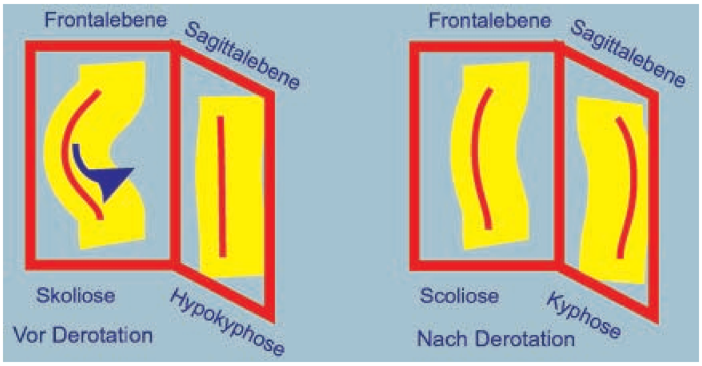


Abb. 11 ▲ **Derotationsmanöver nach Cotrel und Dubousset. Der konkave Stab wird an die Wirbelsäulenkrümmung angeglichen. Die Krümmung wird aus der Frontalebene in die Sagittalebene gedreht. Aus der skoliotischen Seitneigung entsteht eine erwünschte Kyphose**

tion der Wirbelsäule in das Körperzentrum und nach dorsal im Sinne einer Kyphosierung ([14]; Abb. 11). So wird auch ein Rippenbuckel durchaus kosmetisch verbessert, da eine thorakale Hypokyphose diesen besonders betont, und diese korrigiert werden kann. In den nicht rigiden Abschnitten der Wirbelsäule werden die angewandten Rotationskräfte eher wirken. Dies führt insbesondere bei rechtskonvexen thorakalen Skoliosen mit lumbaler Gegenkrümmung zum Phänomen der Dekompensation. Dabei wird die Lendenwirbelsäule ungenügend korrigiert, und es entsteht meist eine Verlagerung des C7-Lots nach rechts [4].

Bei Korrekturen vom vorderen Zugang wird ebenfalls das Korrekturprinzip der Derotation verwendet [11]. Da es auf einem relativ starrem Stab beruht, entstehen häufig Probleme mit der Rotation eines stark vorgebogenen Stabes. Das Verfahren hat aber den Vorteil, dass im Gegensatz zur Kompression vom ventralen Zugang belastungsfähige Stäbe verwendet werden können, welche eine korsettfreie Nachbehandlung erlauben, so wie dies auch für dorsale Instrumentationen der Fall ist. Auch kommt dieses Prinzip bei den ersten Versuchen der thorakoskopischen Instrumentation von Skoliosen zur Anwendung.

Der Korrekturmechanismus der *Translation* kann auf unterschiedliche Weise erfolgen. Wirbelsäulenabschnitte können in Richtung eines Stabes gezogen werden, der an Endwirbeln der Krümmung befestigt ist und entsprechend der gewünschten Form der Wirbelsäule vorgebogen ist. Oder ein Stab wird an einem Wirbelsäulenabschnitt befestigt und dann an einen anderen angenähert (Abb. 12). Da die Translation zu keiner wesentlichen Dehnung des Myelons führt, ist sie relativ risikoarm. Da auch bei Fixation beider Endwirbel weniger Kräfte auf nicht fusionierte Anteile der Wirbelsäule wirken, scheint die Dekompensation seltener vorzukommen. Somit erscheint die Derotation als ideales Korrekturprinzip in der dorsalen Instrumentation von idiopathischen Skoliosen.

Bei juvenilen Kyphosen wird ebenfalls meist von dorsal das Korrekturprinzip der Translation angewandt. Meist werden die kranialen Abschnitte der Wirbelsäule mit einem Stab verbunden, der die zu erzielende sagittale Krümmung der Wirbelsäule vorgibt. Dieser Stab wird dann an die kaudalen Krümmungsabschnitte der Wirbelsäule angenähert und mit ihnen verbunden (Abb. 13).

### Fixation eines Stabes an der Wirbelsäule

Fast alle vorderen und hinteren Implantate zur Korrektur von juvenilen Kyphosen und idiopathischen Skoliosen bestehen aus einem oder zwei Stäben. Diese werden mit unterschiedlichen Implantaten mit der Wirbelsäule verbunden. Dorsal sind folgende Fixationen häufig:

- Sublaminäre Drahtcerclagen,
- Pedikelschrauben,
- Haken von oben: am Proc. transversus, an der Lamina,
- Haken von unten: an der Lamina, im Gelenk, den Pedikel fassend,
- Hakenklammern: monosegmental, bisegmental.

Jedes dieser Implantate kann für bestimmte Zugrichtungen und Konditionen ideal sein, für andere wieder nicht. *Haken* sind leicht zu fixieren und relativ risikoarm, sie können aber zum Beispiel bei einem Derotationsmanöver Richtung Myelon gedreht werden oder bei der translatorischen Annäherung eines Stabes an die Wirbelsäule bei juvenilen Kyphosen Richtung Myelon gedrückt werden.

*Pedikelschrauben* sind fast universell einsetzbar. Kräfte können besser als mit Haken übertragen werden, was zu besserer Korrektur führt [2]. Seit kurzem erscheinen auch Berichte, die zeigen, dass diese selbst bei Kindern während des Wachstums ohne Problem verwendet werden können und kein Fehlwachstum des Wirbels induzieren. Wegen des gerade in der Brustwirbelsäule oft sehr geringen Pedikeldurchmessers werden sie jedoch häufiger in der Lendenwirbelsäule verwendet. Fehlplatzierte Pedikelschrauben verursachen häufig neurologische Ausfälle.

Bei vorderen Instrumentationen stehen nur *Wirbelkörperschrauben* zur Verfügung. Sollen die maximal anwendbaren Korrekturkräfte erhöht werden,

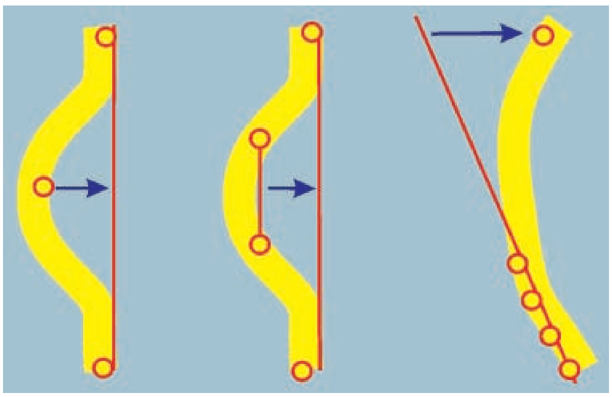

Abb. 12 ▶ **Verschiedene Möglichkeiten der Korrektur durch Translation. Die Ringe symbolisieren fixierende Implantate wie Haken, Schrauben oder Cerclagen**

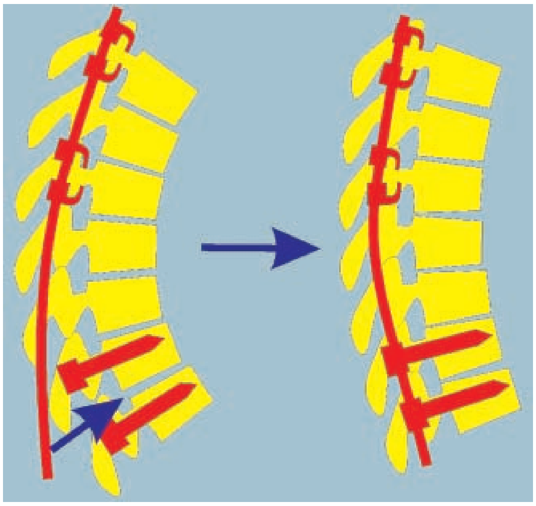

Abb. 13 ◀ **Der Stab wird proximal durch Hakenklammern befestigt. Seine Biegung gibt die antizipierte Wirbelsäulenform vor. Der Stab wird an Pedikelschrauben angenähert**

so kann eine Doppelschraubenkonstruktion gewählt werden, welche die Ausreiß- und Scherkräfte um ca. 1/3 anheben lässt [22].

## Fazit für die Praxis

**Der Behandler idiopathischer Skoliosen und juveniler Kyphosen muss sich bewusst sein, dass er großteils kosmetische Probleme behandelt, manchmal vergesellschaftet mit Schmerz. Das Operationsverfahren muss mit Augenmaß gewählt werden, um das Risiko in einer günstigen Relation zum Operationsziel zu halten. Andererseits darf das Operationsziel des besseren kosmetischen Resultats nicht aus den Augen verloren werden.**

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## Anatomie, Physiologie, Histologie und Pathologie der Wirbelsäule

***Pre-eLearning Literaturempfehlung***


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### Anatomie

*„Der Rücken mit seinem Rückgrat, das dem Mark im Rücken einen Weg bereitet, wird geteilt in Hals oder Nacken, Brust, Lenden, Kreuzbein und Steißbein…"*

Andreas Vesalius: De humani corporis fabrica (1543)



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§ Die 3. Figur der Beine

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