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Treatment Methods and Efficacy of Adolescent Scoliosis

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Abstract. The use and conditions of different treatment methods vary, so choosing the appropriate treatment method for adolescent scoliosis is crucial. This article explores the main treatment methods for scoliosis, including stent therapy, exercise therapy, surgical treatment, and hand therapy. Stent therapy involves various types, such as cervical thoracolumbar sacral stents (such as Milwaukee stents) and thoracolumbar sacral braces (such as Boston stents), with different applicability and efficacy, but compliance and curve characteristics can affect the results. Schröder therapy, core muscle exercises, and SEAS exercise therapies focus on self correction and functional recovery, showing effectiveness in preventing progression, but have limitations in duration and applicability. Surgical treatment (posterior, anterior, combined, minimally invasive) is suitable for severe cases (usually Cobb angle>50°), but it can cause trauma and complications. Hand therapy (acupuncture and moxibustion, massage, chiropractic) is effective for mild cases with high efficacy, but needs long-term application. Each method has its advantages and disadvantages, and the choice depends on factors such as the severity of the curve, patient age, and compliance.

Keywords: Adolescent Idiopathic Scoliosis, Brace treatment, Exercise therapy, Surgical treatment, Hand therapy.

1. Introduction

Scoliosis is a three-dimensional structural and morphological anomaly of the human spine, characterized by a long course of illness and difficult short-term recovery. This situation has a significant adverse impact on the patient's appearance and daily life. If not detected and treated in a timely manner, it may lead to serious progression of spinal deformities, which may damage the normal function of the heart and lungs. In clinical practice, scoliosis is mainly manifested as scoliosis, usually accompanied by vertebral torsion. The diagnosis is defined as a spinal curvature angle>10 ° measured by the Cobb method on standing spine X-rays. The etiology of scoliosis is not fully understood, and potential associations have been found in bone marrow mesenchymal stem cells, genetics, spinal biomechanics, nervous system, hormones, biochemical factors, environmental influences, and lifestyle. Epidemiological studies have provided valuable insights into its prevalence [1]. Soucacos et al. conducted a large-scale screening of 82901 children aged 9-14 and identified 1436 adolescent idiopathic scoliosis (AIS) patients, with an overall male to female ratio of approximately 1:2.1 (note that this ratio varies with increasing curvature angle). In 2013, Konieczny et al. synthesized global data and reported that the overall prevalence of AIS was 0.47% -5.2%, with

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a male to female ratio of 1:1.5 to 1:3, significantly increasing with age. It is worth noting that girls show a higher incidence rate in cases with larger Cobb angles: for angles between 10 ° and 20 °, the male to female ratio is 1:1.4, and for angles>40 °, this ratio rises to 1:7.2, although these statistics do not include data from China. In 2017, Academician Qiu integrated large sample screening studies across China, and reported that the incidence rate of scoliosis in children aged 8-14 years was between 0.6% and 2.0%. Idiopathic scoliosis accounts for about 90% of all cases of scoliosis, with AIS occurring between the ages of 10 and skeletal maturity [2]. The incidence rate in the adolescent population is 0.47% -5.2%. Due to the multidimensional bending and deformation of the spine, vertebrae, and chest cavity, AIS often leads to motor dysfunction and restricted chest movement [3]. The current strategies for treating scoliosis vary depending on the severity of the curvature. Mild cases usually only require monitoring, and curves between 20 ° and 40 ° typically require stent treatment (such as Boston, Charleston, or Milwaukee stents), while curves greater than 40 ° may require surgical intervention, including fusion or non fusion surgery [4]. In addition, exercise therapy and manual therapy have been applied both domestically and internationally. However, the clinical research of adolescent scoliosis treatment mainly focuses on a single model, lacking systematic integration and comparative analysis of various methods. In this context, the aim of this study is to systematically review and evaluate the treatment methods and efficacy of adolescent scoliosis, providing comprehensive references for clinical practice.

2. Brace treatment

2.1. Cervicothoracic Lumbosacral Brace (CTLSO)

The Milwaukee Brace (Milwaukee Brace), a commonly used high-attitude brace, was originally developed by Blount et al., the world's first brace widely used in scoliosis treatment, consisting of a pelvic section (mainly made of plastic), anterior and posterior struts, and a neck ring with a laryngeal mold at the front and a pillow pad at the back. It is mainly used for patients with curve vertices above T8. The brace had poor compliance, i.e., poor patient compliance, with a surgical progression rate of 22% among 1020 patients in the largest study of patients treated with this brace. However, patients with a curve > 30° and Risser signs of 0 to 1 appear to have a higher probability of surgical treatment [2].

2.2. Thoracolumbosacral Brace (TLSO)

TLSO includes Boston braces, Wilmington braces, Lyon braces, Chêneau braces, and Chêneau Light Brace. The Boston brace is mainly recommended for adolescent patients with idiopathic scoliosis between 20 ° and 59 °. A study treated 295 patients with the Boston brace system, with 49% of patients maintaining the same main curvature and 39% ultimately correcting 5 ° -15 °, effectively preventing the progression of the large curve for an average of 9.8 years after discontinuation. But although the brace is more effective in controlling the scoliosis line, it is recommended for the curve between T6 and L2 while guaranteeing that it will be worn for 18 hours a day to be effective [2]. Wilmington branch is beneficial for improving idiopathic bending at 20 ° -39 °. The brace has the same design as the tights with a front opening, with some adjustable straps to secure the brace, and the brace body structure is made of symmetrical hard material. Compared with other braces, the brace is smaller in volume and lighter in weight, which can improve patient compliance. In the 79 patients included in the study, although the magnitude of the curve was usually reduced by about 50% when the brace was initially used, this initial improvement gradually disappeared during active

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treatment and after the patient stopped bracing therapy. Although the curve progressed more than 5° at follow-up in 27 patients (i.e., brace failure), only 11% of patients progressed to the point requiring surgical treatment [2]. Lyon brace is adjustable, active, decompressive, symmetrical, stable and transparent due to its transparent nature; the pressure of the shell on the skin can be directly controlled. It is made up of two aluminum rods in the front and back that connect the armpit, chest, waist and pelvis parts. The indications for use of this brace are the same as those of other braces. However, it is not recommended for non-adolescent adolescents and infants with spinosigus. Bend to avoid a tubular thorax and do not use in patients with severe thoracic lordosis [2]. Chêneau brace is like a three-dimensional system with three brace zones that eliminate rib bulges without the limitation of respiratory performance. The main mechanism of this brace is to correct the spine in three dimensions based on multi-point pressure zones, push the body to its curve through swept pads, and push it into the contralateral space, which is not only a lateral force, but a combination of lateral force and traction. In some cases, the Cheneau brace seems to work for correct curvature [2]. Chêneau Light Brace is assembled from four polyethylene housings, two uprights and straps with attachments. It is only suitable for right chest and left lumbar curvature, and is not allowed for patients with a small brace torso and children under 10 years of age. The advantage of this brace is that it can be used immediately, has been adjusted, and is easy to modify, but during the rapid development of the patient, the curve may increase sharply, and the arrangement of different shells may vary greatly in the process of adjusting the brace. In the report, the Cobb angle was reduced by an average of 16.4° in the entire group in the included (n=81) patients, which is equivalent to a corrective effect of 51% [2].

Since the Milwaukee stent was performed, several types of stents have been produced and trialed, and patients often abandon them due to difficulty wearing them. The thoracolumbar orthosis (TLSO) brace which is lighter, more comfortable and less visible to the patient. Among them, the Boston stent is most effective in scoliosis, with a vertex between T6 and L4 and a curve of 20 to 49 degrees. When the curve is above T6, it is usually not as useful [4]. Therefore, if the patient's apex is between T6 and L4 and the curve is 20 to 49 degrees, the Boston brace is the best choice.

2.3. Flexible brace

Triac Brace (3C Brace) can only be used on curves below T11. The brace consists of a strap that follows the patient's movements. The immediate correction rate is 22% for the first curve and 35% for the second curve, and the point is that it provides a dynamic correction force to correct scoliosis [4]. SpineCor Brace is recommended for mild and moderate curves, but the efficacy is currently not being studied and evaluated [2].

2.4. Night brace

Charleston Brace, Both Milwaukee and TLSO stents require patients to wear them for 18 to 23 hours a day to be most effective. To improve patient compliance, Frederick Reed introduced this night brace in 1979 [5]. In the study, 95 patients (87 girls, 8 boys) were 10 years of age and older, Risser 0-2, had a major curve range of 20°-40°, and had not received prior treatment, and were effective compared to previous natural history and conventional brace study structures. Patient compliance can be improved. However, the success rate of this brace is low in immature patients and in patients with large curves, high main curve tips, double main curves and single thoracic curves [2].

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TLSO was compared to the Charleston and Milwaukee stents and TLSO was found to be better in preventing curve progression. Janicki evaluated the effectiveness of the Providence night stent and TLSO using the SRS criteria. A total of 85% of TLSO and 69% of Providence groups progressed more than 5°, while 79% of TLSO and 60% of Providence required surgery. The authors concluded that Providence was more effective for curves below 35%, but the overall high failure rate compared to other studies may cast doubt on the quality of the stent design in this study [6]. To compare the effectiveness of Milwaukee, TLSO, and Charleston stents in the treatment of AIS. For scoliosis of the thoracic cavity or hyperblication, the Milwaukee brace is mainly used. TLSO, such as the Boston brace, is commonly used for single lumbar and thoracolumbar curves at or below T8. Therefore, a direct comparison of these brackets may not be applicable because the curves are in different positions. Also, since the Milwaukee stent is primarily used for hyperbolas, comparisons to TLSO or Charleston stents may not be effective [5]. Braces also have their shortcomings, such as age, gender, mature Cobb angle, treatment adherence, in-brace correction, and other related factors affecting brace treatment.

3. Exercise therapy

Schroeder therapy, based on sensorimotor and kinesthetic principles, including corrective exercises, postural self-correction, breathing techniques, education, and home exercises, enables the patient can learn to visualize his or her deformity and thus self-correct the wrong posture. The hand on the costocarina side grabs a higher rod in order to rotate the shoulder strap, which must be adducted on that side and the costocarina itself must move forward at the same time. The therapist assists in stabilizing the patient to some extent to help her adapt to the different rotational breathing movements. And use your hands to enlarge the narrow part on the right side to allow air to flow in and guide the patient to breathe. It compares with traditional traction, massage and other passive treatments. Schroeder therapy pays more attention to the cultivation of patients' autonomous control ability, providing an effective way for non-surgical intervention for scoliosis [7]. Core muscle exercises include prone stretches, side stretches, supine leg raises, etc. It improves neuromuscular control, strength, and endurance of different muscles around the spine to correct and maintain spinal alignment. One of the purposes of core exercises for scoliosis treatment is to improve spinal stability [7]. Rehabilitation exercise prescription is better than that of the control group in terms of mental health, physiological functioning and social functioning. The American College of Sports Medicine (ACSM) recommends that the exercise heart rate of adolescents should be controlled at 120 ~ 140 beats/min, and the maximum heart rate of 60% is the threshold for adolescent training intensity. The frequency gradually increases from 2 ~ 3 times a week to more than 5 times a week. Exercise prescription should be in line with the characteristics of adolescents' growth and development, step by step, not overnight, to ensure the safety of adolescents, train without harming physical and mental health and affecting normal development, and avoid injuries during exercise. Breathing training strengthens diaphragm movement and coordination through active relaxation and contraction of the abdominal muscles. Thoracic expansion and limb movement change breathing patterns, reduce respiratory muscle oxygen consumption, and increase respiratory exercise efficiency. Guaranteed breathing depth, fill the concave side with air and promote correct posture with trunk and limb movements. Therefore, it is believed that it can be promoted [3]. SEAS performs treatments for 40 minutes at least twice a week. SEAS uses a teamwork approach that involves clinicians and family members to produce successful patient outcomes [8].

Seventy-four consecutive outpatient adolescent idiopathic scoliosis patients were studied, with a mean Cobb angle of 15° (standard deviation 6), 12.4 years (standard deviation 2.2), at risk of brace,

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and no previous treatment. There were 35 cases in the SEAS treatment group and 39 cases in the conventional physiotherapy group. The primary outcomes included the number of patients with a brace, Cobb angle, and trunk rotation angle. 6.1% of patients in the SEAS therapy group and 25.0% of patients in the conventional physiotherapy group required support. In the worst-case analysis, treatment failure rates were 11.5% and 30.8%, respectively. In both cases, the difference was statistically significant. Cobb angle improved in the SEAS exercise group but worsened in the conventional physiotherapy group. In the SEAS training group, 23.5% of the patients improved and 11.8% of the patients deteriorated. In the conventional physiotherapy group, 11.1% of patients improved and 13.9% deteriorated. These data confirm the effectiveness of exercise in patients with scoliosis at high risk of progression. SEAS appears to be more effective compared to non-adaptive exercise [9].

Judging from the investigation of the above exercise therapies, Schroeter therapy and rehabilitation exercise prescription combined with breathing training have similar purposes, both of which are exercise therapy combined with breathing training, and the efficacy of these two types of training is very good. SEAS emphasizes the role of sports training in aligner treatment, which is more effective but requires higher facilities and requirements. Therefore, if there are no special problems, it is recommended to use Schroeder therapy and rehabilitation exercise prescription combined with breathing training. Core muscle exercises are more inclined to be practiced at home, and can be practiced at home after each treatment to assist treatment. Although exercise therapy is more effective in the overall treatment, exercise therapy also has its shortcomings, such as the limitations of exercise rehabilitation in patients treated for adolescent scoliosis, the Cobb angle, and the long duration of exercise rehabilitation training.

4. Surgical treatment

Surgical treatment is divided into posterior surgery, anterior surgery, anterior-posterior combined surgery and minimally invasive surgery. Posterior surgery is the first effective internal fixation system for the treatment of scoliosis was reported by Harrington in 1962, correcting the scoliosis deformity through the internal fixation of the metal genus and the support and compression. The advantage of Posterior surgery can reduce the need for fusion segments and low surgical risk. This treatment method can obtain better orthopedic results, reduce the number of nails, shorten the operation time, and reduce the financial burden of patients [10]. The main eligibility of Anterior surgery are the curvature of the thoracolumbar and lumbar sections, and the removal of the intervertebral disc and the intervertebral bone grafting increases the postoperative fusion rate. At the same time, the fusion of the front road can break the growth center of the front and prevent the occurrence of the crankshaft phenomenon. The advantage of Anterior surgery is suitable for patients with congenital defects in the thoracolumbar, lumbar and spine who cannot use the posterior surgical method, and can effectively correct the curve in the sagittal plane, and the scoliosis in the sagittal plane can be better corrected [11]. But its disadvantages are that it has deficiencies such as pseudoarthrosis, internal plant failure, great trauma, and excessive bleeding [10]. Combined anterior-posterior surgery for AIS patients with a Cobb angle greater than 75 and stiffness (scoliosis correction of less than 50 degrees on spinal X-ray in the lateral curvature position), the effect of simple anterior fusion fixation on the correction and appearance improvement of severe deformities is limited. In order to achieve a satisfactory scoliosis correction rate and fusion rate, the current common treatment plan at home and abroad is anterior release plus posterior orthopedics. At present, most of the anterior-posterior combined procedures can be completed in one phase, and for particularly severe scoliosis, it is necessary to perform in stages, and the first stage is advanced to

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the release of the front and back paths, and then the front and rear instruments are fixed after 1~2N. The advantage of Combined anterior-posterior surgery can improve the flexibility of the spine, improve the degree of motion of the spine to improve the correction rate, stabilize the spine and reduce complications, and combine the posterior route to achieve better correction and fixation. It can effectively relieve thoracic scoliosis with little trauma, clear exposure and can achieve the same ideal correction effect [10]. The advantage of minimally invasive surgery can reduce muscle separation, cause less trauma, have less impact on respiratory function, and a short recovery time. It has the advantages of low bleeding, short operation time, fast postoperative recovery, and no anesthesia [10].

Many surgeons believe that 50° is a sign of surgical treatment for scoliosis. In part, most of the 50° curves are very noticeable in appearance. However, there are other factors to consider. In addition, rotational dislocation, metaphysis metastasis, and sagittal deformity but the chest curve is larger than the lumbar curve, and the ratio of the lumbar curve to the chest curve plays a role in determining whether surgical treatment is recommended for the chest more flexible. Another problem is that the patient is close to skeletal maturity. If the patient is immature, then progress may be faster. At the same time, if the brace treatment fails, surgical treatment will also be recommended [11]. The shortcomings of surgical treatment are mainly complex, difficult, traumatic, and complicated, which require a strict grasp of surgical indications, correct classification, correct selection of approaches and surgical methods, and strict operation during the operation to minimize the incidence of complications. Therefore, if the patient's condition is not particularly serious, it is not necessary to undergo surgical treatment, and try to choose a brace or exercise therapy to control to avoid the trauma and complications of surgery.

5. Hand therapy

Orthopedic joint acupuncture method is a characteristic method of treating traumatic diseases, relaxing the contracture soft tissue and then carrying out osteopathic techniques can effectively correct the displaced vertebrae, restore the anatomical position of the joints, correct scoliosis, and combine with acupuncture to regulate the qi and blood of the meridians [10]. Traditional Chinese medicine comprehensive treatment based on massage can relax the meridians, harmonize qi and blood, relieve muscle spasms, and relieve the "bowstring effect" at the largest part of the scoliosis. Tuina combined with acupuncture, exercises, traditional Chinese medicine therapy, etc., is also widely used in the clinical treatment of AIS, with significant efficacy, and it is also an important principle to instruct patients to perform rehabilitation functional exercises [10]. Electroacupuncture chiropractic techniques can correct the deviation of the spinous process and change the displacement of the vertebral body, and the main representative techniques include the spine pushing method, the double palm stacked pressure spine method, and the lumbar extension extension method. Chiropractic techniques combined with acupuncture and spine training have good curative effects, but attention should be paid to the whole. During the treatment of chiropractic manipulation with acupuncture and spinal training, rigidity and softness should be combined, and the operation should not be rough to avoid causing new injuries [10]. Flat chiropractic method corrects abnormally displaced spine and abnormal posture by adjusting the muscles and ligaments around the spine and relieving muscle spasms. Flat spine therapy is a method of restoring spinal balance based on Pingle orthopedic and tendon repair therapy, with significant clinical efficacy [10].

According to multiple experimental data, it has been proven that no matter which method, its effectiveness is higher than that of the control group treated with other methods, and it is more than 90%, and even the effective rate of massage combined with electroacupuncture can be as high as

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100%. This demonstrates that manual therapy is particularly effective, but it takes a long time and is only suitable for milder patients. This method can be chosen if the patient's condition is mild. If the patient's condition is slightly severe, it is still recommended to choose brace therapy or exercise therapy.

6. Conclusion

Brace therapy has a good therapeutic effect, but there are related factors such as age, gender, mature Cobb angle, treatment compliance, and in-brace correction. The effectiveness of exercise therapy in patients with scoliosis at high risk of progression, but the Cobb angle in the treated patients has limitations and treatment is too long. Surgical treatment has a good therapeutic effect on very severe scoliosis, but surgical treatment is complex, difficult, traumatic, and complicated, so it is necessary to strictly grasp the surgical indications, correctly classify, correctly choose the approach and surgical method, and operate strictly during the operation to minimize the incidence of complications. Manual therapy works better, but only in patients with milder conditions. Overall, various methods have their effects and disadvantages, and the right method should be chosen according to the different conditions of the patient. Today's research on adolescent scoliosis is not comprehensive enough, and it is still the direction of efforts to explore treatment methods with fewer drawbacks and a wider range of treatment.

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