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THE OUTCOME OF ANTERIOR RELEASE, POSTERIOR INSTRUMENTATION AND CIRCUMFERENTIAL FUSION IN SCHEUERMANN'S KYPHOSIS

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SUMMARY

Scheuermann's kyphosis is generally treated conservatively. Surgery is reserved for patients with high-degree progressive kyphotic deformities and in patients with pain and neurological deficits. The most preferred surgical approach is posterior instrumentation and fusion. The risks associated with posterior approach include correction losses and pseudoarthrosis. Therefore, recently combined anterior and anterior fusion procedures are more frequently used. Studies reporting on the long term outcome of surgical and clinical treatments for Scheuermann's kyphosis are not many in number. Our study population consisted of 20 young adults with a kyphotic deformity greater than 70° who underwent anterior release, posterior correction with 3rd generation instrumentation, and anterior-posterior combined fusion and who were followed for at least 5 years. Preoperative, postoperative and final visit global thoracic and apical intersegmental kyphosis angles were assessed radiologically and the percent correction was determined. Clinically, patients were evaluated with SRS22 questionnaire. All patients were male with a mean age of 18.2 ± 2.1. Preoperatively, the average kyphotic angle was 89.2° ± 17.9°, and postoperatively it fell down to 40.6° ± 14.3°, with a 45.5% ± 13.1% correction. The apical intersegmental angle was 24.6° ± 5.3° preoperatively, and it was reduced to 4.9° ± 2.0° postoperatively. A statistically significant correction was observed in both global thoracal and apical intersegmental kyphosis angles ($p < 0.05$). No early or late infections, neurological deficits, or systemic complications occurred. In patients who received CTLSO treatment for 4 months, an average correction loss of 3.7° ± 1.4° was detected at the final visit. With regard to SRS22 scores, scores equal to or greater than 4 were obtained in all patients for all domains, and the average scores for pain, function, personal appearance, mental status, and satisfaction with treatment were 4.8 ± 0.3, 4.5 ± 0.4, 4.6 ± 0.5, 4.5 ± 0.5 and 4.7 ± 0.4, respectively. The domain scores for personal appearance, mental status, and satisfaction with treatment showed a positive correlation with postoperative percent correction and a negative correlation with correction loss. Eighteen patients (90%) became completely free of pain, and the remaining 2 patients had a correction loss greater than 5°. In the light of these data, we suggest that in young adults with Scheuermann's kyphosis and a thoracal sagittal angle greater than 70°, it is possible to achieve normal sagittal contours with an intervention consisting of anterior release, posterior correction with 3rd generation instrumentation, and circumferential fusion. Also, it seems that this surgical treatment method together with the use of Milwakuee brace for 4 months result in a low incidence of correction loss as well as satisfactory clinical and cosmetic results.

Keywords: *Scheuermann's kyphosis, adolescent kyphosis, surgical treatment, SRS22 questionnaire, long-term follow-up*

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INTRODUCTION

Scheuermann's kyphosis is a developmental spinal deformity with an unknown etiology characterized by deformation of sagittal contours. This entity was originally described by Scheuermann as "idiopathic juvenile kyphosis" in 1921[15]. At that time, the disease was considered as an avascular necrosis, and the many theories that were then put forth regarding the etiology of the disease have not been proven. Many studies on Scheuermann's kyphosis examined conservative treatment methods, and the widely accepted therapeutic approach is orthosis[17].

Bradford, in his study in 1974, concludes that the only and the most important option in the treatment of patients with Scheuermann's kyphosis is a conservative method[9]. Bradford suggests that surgical treatment is usually not needed. Most of the studies before 1980 seem to support Bradford's conclusions, and treatment based on orthosis and supported by postural exercise programs were reported to achieve satisfactory results[15,17].

Speck and Chopin (1986), and Otsuka et al. (1990) suggested that orthosis was definitely effective in preadolescent children, however the exercise program had no effect on the control of curvature and surgery should be reserved for patients who have significant spinal curvature, pain resistant to medical treatment, and neurological deficits[22,28]. According to Herring (2002) conservative treatment should be used in patients with known progressive disease but with a cosmetically and functionally acceptable kyphotic deformity who have not yet achieved skeletal maturity (Risser 2 or below)[14].

A literature review for the last 20 years indicates a definite consensus on the use of orthosis in skeletally immature patients. In same papers it is noted that conservative methods may initially show some beneficial effect on the kyphotic deformity, however significant correction losses may occur during the follow up period, and eventually only a mild to moderate efficacy with regard to the correction of kyphotic deformity could be achieved[15,17,18,31].

From 1921, which is the year the disease was described, to 1975, the literature on the surgical treatment of the disease has been scarce[17]. In 1975, Bradford and his colleagues reported their results on the surgical treatment of the disease in 22 patients, and no other studies were published in the literature. In that study, Bradford et al. recommended surgical treatment with Harrington compression rods[10]. In 1993 Murray, Weinstein and Spratt published a study on the natural course and the long term outcome of the disease[21]. In patients reaching adulthood with a kyphotic deformity below 60°, no progression is expected[15]. Lowe proposes that surgical treatment is indicated in patients unresponsive to medical treatment who have a kyphotic deformity greater than 70°[17,18].

Freeman, suggests that in recent years this method is being more frequently preferred due to the fact that it is a cosmetic deformity that responds to orthotic therapy modestly[12]. Basic corrective maneuver is compression applied posteriorly with instrumentation. Most of the studies on surgical treatment examined posterior instrumentation techniques. In patients undergoing posterior instrumentation only, significant correction losses have also been reported[15,17-18]. Therefore, Speck and Chopin, by considering their results on 59 patients, concluded that best results can only be achieved by combined anterior and posterior surgery[28].

The study subjects consisted of 20 consecutive young adults with a kyphotic deformity greater than 70° who underwent anterior release, posterior correction with 3rd generation instrumentation, and circumferential fusion. Patients were fol-

lowed for at least 5 years to evaluate correction losses, fusion rates, patient satisfaction.

PATIENTS AND METHODS

A total of 20 adolescent patients with idiopathic kyphosis with no other identified etiology were included in the study between January 1989 and January 2000. The mean age was 18.2 ± 2.1 (range: 17-20). All patients were male. In addition to cosmetic complaints, patients had discomfort while lying on their back, and back pain unresponsive to medical treatment following long lasting exercise. Neurological examination was normal. Radiologically, in addition to antero-posterior and lateral images, "fulcrum" radiographies were also obtained while the patients were standing. Cobb's method was used to measure the global kyphosis angle between the 2nd and 12nd thoracal vertebrae in the lateral views. Intersegmentary angles were determined by measuring the angle between the lines drawn through the upper and lower endplates of all the vertebrae involved in the kyphosis. In fulcrum images, the correction rates for intersegmentary and global kyphosis angles were determined. A diagnosis of Scheuermann's kyphosis was made if intersegmentary angles were greater than 5° in at least three levels and the global kyphotic deformity greater than 70°, in the lateral images obtained while the patient was standing.

With respect to classification of Scheuermann's kyphosis, patients with progressive kyphosis in the thoracal region were considered Type I, patients with kyphosis in cervicothoracic region were considered Type II, and patients with lumbar kyphosis were considered Type III[17]. In 1997, Gennari et al. proposed a new classification system with the following four categories: high thoracal kyphosis (Type I), middle thoracal kyphosis (Type II), low thoracal or thoracolumbar kyphosis (Type III), complete thoracal kyphosis (Type IV)[13]. All patients were Type I according to the previous classification and Type IV according to Gennari classification.

In all patients, regular Scheuermann's kyphosis involving complete thoracal area with an apex at 7th and/or 8th vertebra was detected and a decision for surgical treatment was made. Indications for surgery were as follows: significant back pain; bone development stage reached to Risser 4-5; a curvature greater than 70°. Also, a good bone mineral density was required.

Following routine laboratory and clinical examinations, all patients were operated by Dr. Benli in SSK Ankara Research and Training hospital. Final visits were performed at the same institution in September 2005.

For surgery, anterior intervention was preferred, and following thoracotomy in lateral decubitus position, vertebrae were reached. Following the excision of anterior longitudinal ligament, intervertebral discectomy was performed by the removal of end plates with a small osteotomy device. These procedures were performed minimally in 5 levels and maximally in 7 levels located in the apical region of the kyphosis that had an intersegmentary angle of at least 5°. An intraoperative distractor was used to check whether adequate intervertebral release was achieved. To perform anterior fusion, tricortical grafts cut off from the ribs that were removed during thoracotomy were placed anteriorly as supportive grafts in each discectomy level together with autologous spongious grafts. Surgical levels were closed orderly, and then thorax tube was placed and closed-water drainage was provided. In the same session, patients then were placed in prone position and posterior intervention was performed. In one patient Cotrel-Dubousset instrumentation (CDI) and in 19 Texas Scottish Rite Hospital (TSRH) system was used.

In addition to the transversopedicular claws placed on top, compression hooks and screws were placed up to the apical region. Then, two rods, prebend at least to the degree of correction rate in the fulcrum images, were placed bilaterally by the claws and hooks simultaneously. These were fitted to the hooks and transpedicular screws in the compressive mode by cantalever method to exert compression. Next, posterior fusion with autologous grafts was performed. Postoperatively, patients were made to sit on day 1, and were encouraged to stand and walk on day 2. Patients used vitraten mold, Milwaukee brace (CTLSO) for 4 months after the operation.

Thoracal kyphosis angles were measured pre- and postoperatively and at the final visit. If present, the Cobb angle of the scoliotic curvature in frontal plane was measured. Correction rates were determined. Fusion was ascertained on the basis of anterior intervertebral consolidation, the presence of posterior fusion mass as well as the presence of a correction loss below 5°. A correction loss between 5 and 10° was considered fibrous fusion; and a loss greater than 10° with significant back pain and implant failure was considered as pseudoarthrosis. In addition, all early and late complications were recorded and treatment satisfaction was measured by SRS22 questionnaire, which was validated and translated into Turkish by Alanay et al.. Five questions for each of the mental status, pain, function, and personal appearance domains and two questions for treatment satisfaction domain were used. For each question, a 5 point scale was used, and the final scores were determined by dividing the total points by 5 for the first four domains and by 2 for the treatment satisfaction domain. A point equal or greater than 4 was regarded as satisfactory. Statistical analyses were performed by “SPSS for Windows 9.0” software using “Significance test for the difference between different observations among two paired groups” and “Pearson Correlation-Regression Test”. A p value < 0.05 was considered significant.

RESULTS

In preoperative assessments, the average global thoracal kyphotic angle was 89.2° ± 17.9° (70°-109°), and no patients had scoliotic deformities in addition to deformities in the sagittal plane. The global kyphotic angle which showed an average correction of 11.1 ± 9.1% in the fulcrum images was reduced to 40.6° ± 14.3° postoperatively with an average percent correction of 45.5 ± 13.1%. The average apical intersegmental angle was 24.6° ± 5.3° preoperatively, and it showed an average improvement of 4.9° ± 2.0° postoperatively. The improvements in both global thoracal kyphosis and apical intersegmental kyphosis angles were statistically significant ($p < 0.05$).

No early or late infections, neurological deficits, or systemic complications occurred. In patients who received CTLSO treatment for 4 months, an average correction loss of 3.7° ± 1.4° was detected at the final visit. In 18 patients (90%) a correction loss below 5° was detected, while 2 patients (20%) had 6° and 8° correction losses. However no patients including the latter two had significant pain or implant failure, indicating the absence of pseudoarthrosis.

With regard to SRS22 scores, all patients had domain scores equal to or greater than 4, and the average scores for pain, function, personal appearance, mental status, and satisfaction with treatment were 4.8 ± 0.3, 4.5 ± 0.4, 4.6 ± 0.5, 4.5 ± 0.5 and 4.7 ± 0.4, respectively. The domain scores for personal appearance, mental status, and satisfaction with treatment showed a positive correlation with postoperative percent correction and a negative correlation with correction loss. Eighteen patients (90%) were completely free of

pain, and the remaining 2 were the subjects with a correction loss greater than 5°.

DISCUSSION

After the disease was described at the beginning of the 19th century, Scheuermann's kyphosis was considered to be an avascular necrosis of the spine. Today this disease is thought to be caused by an abnormality in the cartilage matrix accompanied by a decrease in glycoproteins or by an extensive juvenile osteoporosis. Yet the certain etiopathogenesis is still unknown. However, definitely a shortening and intersegmentary wedging in the anterior column of the spine occurs due to a developmental defect[12,31]. For a diagnosis of Scheuermann's kyphosis to be made, wedging in at least three levels should be greater than 5° and no other etiological factors (neuromuscular, congenital, etc.) should be present[15,17]. Patients in our study met these criteria with wedging in at least 3 vertebrae together with an average apical intersegmentary kyphotic deformity of 24.6°.

The most important issue regarding the conservative treatment of Scheuermann's kyphosis is the outcome of brace treatment. According to Pizzutillo and Boni et al., compared to idiopathic scoliosis, brace treatment in Scheuermann's kyphosis is associated with a better outcome[8,17,23]. Bradford et al. treated their patients with Milwaukee brace for a total duration of 32 months (full-time for 14 months, and then part-time for the following 18 months), and achieved an average correction of 49% for thoracic kyphosis and 35% in lumbar lordosis; although correction loss was observed in all patients during long term follow up, the final thoracic kyphotic angle was better than the initial values in 69% of the patients. Montgomery and Erwin reported on the use of Milwaukee orthosis in 21 patients (18 months full-time, 6 months part-time) with a correction of 30% in the initial kyphosis and 10% of maximum final kyphotic correction[20]. Lowe suggested that treatment with orthosis is associated with a significant initial improvement in Scheuermann's kyphosis, with a correction loss between 15-30% in the long term, indicating a moderate efficacy[15,17]. On the other hand, Soo et al., in their study comparing Milwaukee corset and Harrington rod found that although influenced by the severity of the curvature and the age at which treatment was given, long-term results do not differ significantly[27]. All these data suggest that the correction rates obtained with corset treatment in Scheuermann's kyphosis are not very high, but despite these seemingly low rates, this approach is effective in achieving a thoracic kyphosis within the physiological range. During the follow up, the correction was partly decreased, but the kyphosis angle was still satisfactory.

In their review, Sachs et al. reported instrumentation failure in patients (n=120) with a kyphotic deformity greater than 74°[25]. The critical angle reported by Montgomery and Ervin was 75°[20]. Murray et al. suggests that in patients with a kyphotic angle below 71°, there was no significant progression during adulthood and there was no need for surgery[21].

The first surgical study with a large sample (n=22) is that of Bradford et al. These authors achieved significant correction with Harrington compression rod; but 16 patients had significant correction loss, 3 patients had infection and 5 had implant failure[10]. Taylor et al. in their 27-patient series, found 15 patients with a correction loss equal to or greater than 5°[29].

In Scheuermann's kyphosis, one of the most controversial issues is the indications for surgical treatment. Lowe and Kasten treated 32 patients with CDI and suggested that the surgery was indicated for patients with a kyphotic angle greater than 75°[16]. Gennari et al. proposed that in pati-

ents with Type I, Type II and Type III Scheuermann's kyphosis, the presence of a kyphotic angle greater than 75°, 82° and 78° showed an indication for surgery[13]. According to Freeman, the definite indication for surgery is a progressive kyphotic deformity greater than 70°. Other indications include progressive neurological deficits and pain unresponsive to medical treatment[12]. On the other hand, it is obvious that indications for surgery have recently expanded due to cosmetic concerns. In our study, the indications for surgery were a kyphotic deformity greater than 70°, severe pain and the presence of cosmetic complaints. The average global thoracic kyphotic angle was 89.2°.

Another controversy in the surgical treatment of Scheuermann's kyphosis is timing of surgery. Speck and Chopin, and Otsuka et al. suggested that orthosis was definitely effective in preadolescent children, however the exercise program had no effect on the control of curvature, and the efficacy of orthosis treatment was mild-to moderate at adolescence age; thus, they state that in this age group surgery should only be used for patients who have significant spinal curvature, pain resistant to medical treatment, and neurological deficits[12,22,28,31]. Freeman proposes that the surgical treatment was most successful in patients near the end of adolescent period[12]. Therefore, in that study surgical treatment was used just before adulthood for Risser 5 patients. However, age homogeneity of the patients included in the study precludes a comparison with other age groups.

Studies reporting on the correction loss in patients undergoing posterior fusion only caused a shift in surgical approaches in the direction of combined fusion techniques. Speck et al. report that the initial complaint was pain in 46% of the patients, and the best results can be achieved with combined anterior and posterior correction and fusion[28]. In 1988, Shufflebarger used anterior release and posterior CDI for 15 patients with Scheuermann's kyphosis; patients were followed for 26 months and the kyphotic angle fell from 81° to 33°, with negligible correction losses[26]. Tribus states that the fusion segment should be extended to include the upper and lower vertebrae of the kyphotic segment, and with short instrumentations very severe kyphosis over the instrumentation is inescapable. Also, according to this author a correction greater than 50% should be avoided, and decompensation and neurological deficits can be improved by this way[30]. Ferreira-Alves, Resina and Palma-Rodrigues in their 38 patient series achieved an average kyphotic angle of 43° with sublaminar wiring, with only 3 patients having a correction loss equal to or greater than 10°[11].

In line with literature data, in the present study we used anterior fusion, correction with posterior instrumentation, and posterior fusion following anterior release in 20 patients with Type I (former classification) or Type IV (Gennari classification), in another words regular Scheuermann's kyphosis. The correction in postoperative global thoracic kyphosis angle was much higher compared to preoperative fulcrum radiographs (45.5%), with all patients achieving normal physiological thoracal kyphosis (30°-50°). The average apical intersegmental angle was preoperatively 24.6°, and it fell down to 4.9° postoperatively. The improvements in both global thoracal kyphotic angle and apical intersegmental kyphosis angle were statistically significant ($p < 0.05$).

No early or late infections, neurological deficits, or systemic complications were noted. In the final evaluation, a minimal correction loss of 3.7° was determined. In 90% of the patients, the correction loss was below 5°, and only in 2 patients a correction loss of 6° and 8° were observed. However no patients including the latter two had significant pain or implant failure, indicating the absence of pseudoarthrosis.

Recently, a subjective questionnaire is also being frequently used in addition to clinical and radiological assessments in the evaluation of scoliosis patients. This questionnaire also assesses the change in patient's life quality[2-7]. There are also studies on different scoring systems, and several versions of these questionnaires have been translated and validated for different countries[3-5,7]. In the current study, the SRS - 22 questionnaire adapted to Turkish by Alanay et al. (also co-author of this study) was used[1]. Our literature search did not reveal any studies that used a patient oriented questionnaire such as SRS-22 for evaluating the long-term outcome of the surgical treatment in Scheuermann's kyphosis. With respect to this, our study is the first to assess clinical results of the Scheuermann's kyphosis with SRS-22.

In SRS22, the average scores for pain, function, personal appearance, mental status, and satisfaction with treatment were ≥4 in all patients. The domain scores for personal appearance, mental status, and satisfaction with treatment showed a positive correlation with postoperative percent correction and a negative correlation with correction loss. Eighteen patients (90%) became completely free of pain, and the remaining 2 patients had a correction loss greater than 5°.

In the light of these data, we suggest that in young adults with Scheuermann's kyphosis and a thoracal sagittal contour greater than 70°, it is possible to achieve normal sagittal contours with an intervention that consists of anterior release, posterior correction with 3rd generation instrumentation, and circumferential fusion. Also, it seems that this surgical treatment approach combined with the use of Milwakuee brace for 4 months result in a low incidence of correction loss as well as satisfactory clinical and cosmetic results.

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