THE EFFECT OF HOOK PATTERN ON THE SAGITTAL PROFILE IN IDIOPATHIC SCOLIOSIS

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ABSTRACT :

Background : *The importance of sagittal profile in idiopathic scoliosis is well known. We know that kyphosis may be present in junctional areas, usually between T12-L1. Distraction forces create or increase junctional kyphosis when instrumentation is ended at T12-L1. That is, one should either by-pass the junctional zone or modify the hook pattern by means of reversing the very caudal hooks.*

Aim: *This study evaluated the effect of reverse hook pattern on sagittal profile on upper-thoracolumbar (T10-T12) and lower thoracolumbar (T12-L2) region.*

Material and Method: *We have identified 31 patients where hooks ended between T11 and L2. (Table 1). Of the 29 cases included in the study, there were 16 females and 13 males, their average age was 15.5 ± 2.11 years. Sagittal profiles of 18 patients where we used classic hook pattern (distraction on concave side) revealed an average of 7° worsening of kyphosis. On the contrary, in 11 patients, where we used a reversed hook pattern (hooks placed in the direction of compression on concave side rod), sagittal profile on T12 - L2 segment preserved or increased the lordotic nature of that segment.*

Conclusion: *Though our reversed hook pattern group is not big enough as the classic hook pattern group, we could say that reversed hook pattern should be used if the instrumentation is going to be ended at T12-L2 segment.*

Key Words: *Hook pattern, Sagittal Profile, Idiopathic Scoliosis*

The goals of surgical treatment of scoliosis have evolved from the correction of the radiographically obvious coronal plane deformity to the correction of the three dimensional deformity of scoliosis. Restoration of normal sagittal plane contours and derotation of the transverse plane deformity are increasingly important surgical goals (5).

As King early emphasized, all right thoracic curves are not the same (10). King et al. (9) described various types of idiopathic scoliosis with right thoracic component. They also recommended fusion levels with the use of Harrington Distraction system. Cotrel-Dubousset system has gained wide popularity and resulted in well established guidelines for fusion levels and hook placement patterns (7). Bending neutralization of disc spaces on coronal bending films and sagittal analysis on standing films are important points in selection of the stragetic vertebra (5, 7, 10). If and when these guidelines are not followed, postoperative balance problems (decompansation) in, so-called, Type II and III curves may arise.

Alıcı Spinal System (1, 2, 3) is one of the 3-D systems has its own hook placement patterns. There are some differences in rational of hook placement with C-D system: first is apical concave "neutral" hook placement, and second, is convex compressive transverse process hook placement (1, 4) Formerly, interest was on the coronal correction and balance of the scoliotic spine, thus reports were concentrated on frontal plane.

Normal sagittal Cobb measurements showed that though upper thoracolumbar junction (T10-T12) might be in slight kyphosis, lower thoracolumbar junction (T12-L2) should be in lordosis (5, 6). Kyphosis in T12-L2 region, especially if greater than +10°, is pathologic and should be considered in the instrumentation of this curve (6, 8).

Hook placement patterns are determined by force direction required to construct the sagittal plane. It should be kept in mind that distractive direction forces produce kyphosis and compressive direction forces produce lordosis. Thus, we believe that sagittal contour should be carefully evaluated and treated accordingly.

The purpose of this report is to evaluate the effect of hook patterns on the sagittal contour of idiopathic thoracic curves.

MATERIALS AND METHODS

Consecutively treated adolescent idiopathic scoliotic curves where distal hooks end between T12 and L2 levels were selected. Alıcı Spinal System (1) were

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used in all cases. Minimum follow-up was 6 months. Standing AP and Lateral films, supine bending films were reviewed. Stable vertebra, T1-Mid Sacral line (MSL) balance determined on AP films, Thoracic kyphosis (T3-T12), upper thoracolumbar junction (T10-T12), lower thoracolumbar junction (T12-L2), lumbar lordosis (T12-L5) lateral Cobb measurements as stated by Bernhardt and Bridwell (5) were done on lateral films Fig (1).

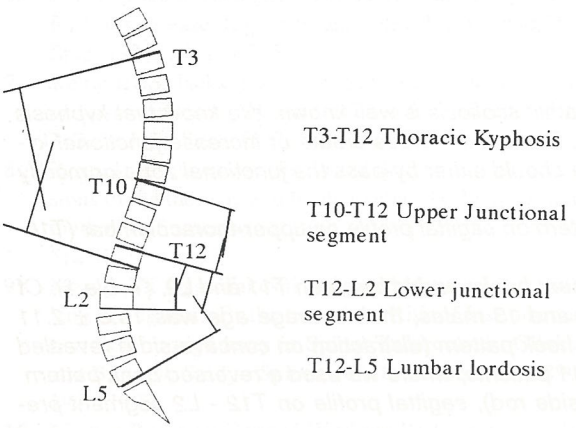

Fig. 1. T3-T12, T10-T12, T12-L2, T12-L5 Lateral Cobb measurements are shown.

31 cases were identified and 29 cases whose preoperative and postoperative films are complete included in the study. There were 16 females and 13 males. Their mean age was 15 years (SD ± 2.11) with a range of 10 to 19 years of age.

Distal hook patterns fall into two groups: A) classical right thoracic hook (CH) pattern where distal hooks exert distraction direction force Fig (2A), B) reverse hook (RH) pattern where compressive direction force is applied on distal instrumented segment Fig (2B).

Wilcoxon rank sum test and Wilcoxon signed rank test were used in statistical analysis.

RESULTS

There were 18 classical hook pattern, 11 reverse hook pattern applied patients. Most frequent lower instrumented vertebra was L1, however when we look at the groups it is seen that L2 was the most frequent end vertebra (9/18) in classical hook pattern group, and L1 (7/11) was in reverse hook pattern group. Table 4.

Curve types are shown on table 1.

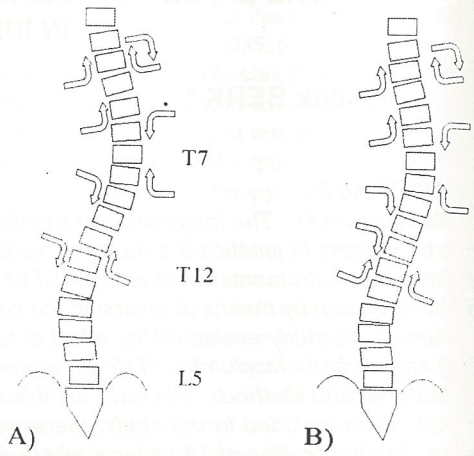

Fig. 2. Arrows indicate direction of force applied. (A) Classical hook placement: Concave side rod ends with a hook placed in a distractive manner. B) Reverse hook placement: Lower distractive hook is carried one level above and at the lower instrumented vertebra some compression is applied between the two lowermost hooks.

Table 1. Curve types in relation to hook patterns are shown.

Curve Type	Classical	Reverse	Total
Right Thoracic/ Left Lumbar	6	4	10
Right Thoracic	8	3	11
Left Thoracic	3	2	5
Double Thoracic	1	2	3
Total	18	11	29

Mean thoracic kyphosis (T3-T12) was 26.2° (SD ± 15.08) ranging from a minimum of 2° to a maximum of 68°. The mean upper thoracolumbar junction (T10-T12) Cobb measurement was 3.83° of kyphosis (SD ± 8.68), ranging from 16° of lordosis to 20° kyphosis. The mean lower thoracolumbar junction (T12-L2) measurement was 5.3° of lordosis (SD ± 5.15), with a range from 18° of lordosis to 2° of kyphosis. Lumbar lordosis (T12-L5) averaged 33.1° ranging from 10° to 62° of lordosis. Table 2.

Tablo 2. Preoperative sagittal contour, change relative to the preoperative sagittal countour and lower instrumented vertebrae are shown.

	T AP		L AP		T3 - T12		T10 - T12		T12 - L2		T12 - L5	
Eğri Tipi	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop
T/L (n:6) Classical	61.6° (44_94)	21.3° (10_45)	39.2° (28_52)	21° (20_28)	24.7° (5_40)	21° (10_40)	1° -16_8)	4.3° (-4_16)	-0.6° (-8_0)	9.5° (-2_23)	-31.6° (-35_-38)	-30° (-25_-45)
T/L (n:4) Reverse	49.5° (44_60)	12.3° (5_20)	29.5° (24_35)	12° (8_14)	28.3° (10_40)	19.7° (12_28)	4.8° (-2_12)	5.8° (3_7)	-9.8° (-18_-4)	-1° (-5_10)	-37° (-30_-44)	-35° (-23_-47)
T/L Total	56.7°	17.7°	36.4°	19.4°	26.1°	20.5°	2.5°	4.9°	-4.3°	5.3°		
Right T (n:8) Classical	44.8° (22_56)	10.6° (2_23)			25.6° (2_45)	20.8° (10_32)	20.8° (10_32)	3.8° (0_8)	-3.6° (-11_2)	1.8° (-10_10)	-31.3° (-13_-53)	
Right T (n:3) Reverse	53° (42_72)	17° (6_30)			22° (18_30)	27.3° (16_34)	27.3° (16_34)	6.6° (4_12)	-8.6° (-4_-16)	-8.6° (-6_-10)	-38.6° (-12_-52)	
Right T Total	47°	12.3°			24.6°	18.8°	18.8°	1.8°	-4.9°	-1.1°		
Left T	38.2°	16.6z	-42.5°		38.2°	34.4°	34.4°	7.8°	-5.8°	0	-33.5°	-29.5°
Double T	11.6°/48.6°	35°/17°	-20°		17.7°	22°	22°	3°	-5.3°	-1.7°	-20°	-36°
Total	51.5° (22_99)	15.5° (2_45)	34.5° (15_52)	13.4° (2_28)	26.2° (2_68)	24.2° (8_44)	24.2z (8_44)	5.4° (-4_16)	-5.3° (-18_2)	1.03° (-10_23)	31.9° (-10_-62)	-30.4° (-18_-50)

Postoperative mean thoracic kyphosis was 24.2° (SD ± 10.82), ranging from 10° to 42°. Mean postoperative upper thoracolumbar junction Cobb measurement was 5.37° of kyphosis (SD ± 4.30), ranging from 4° of lordosis to 12° of kyphosis. The mean lower thoracolumbar measurement was 1.03° of kyphosis (SD ± 7.72) ranging from 10° of lordosis to 23° of kyphosis. Mean postoperative lumbar lordosis was 30.4°, ranging from 12° to 50° of lordosis. Table 2.

Table 3. Mean values and ranges for classical hook pattern, reverse hook pattern in relation to curve types are given.

	T10 - T12		T12 - L2	
Hook Type	Preop	Postop	Preop	Postop
Classical n:18	2.9 ± 4.6° * (-16°_20°)	4.2 ± 4.3° * (-4°_16°)	-3.6 ± 4.1° ** (-11°_2°)	4.2 ± 7.8° ** (-10°_23)
Reverse n:11	5.3 ± 10.5° *** (-10°_30°)	6.9 ± 3.6° *** (1°_12°)	-8.1 ± 5.6° **** (-18°_0)	-4.1 ± 4.2° **** (-10°_4°)
Total n:29	3.83° ± 8.68 (-16°_30°)	5.37° ± 4.30 (-4°_16°)	-5.3° ± 5.15 (-18°_2°)	1.03° ± 7.72 (-10°_23°)
	p = .2467 t = .6943	p = .0445 t = 1.7643	p = .01 t = -2.4725	p = 1.553E-03 t = -3.2475

When two groups, classical hook pattern and reverse hook pattern, evaluated, mean upper thoracolumbar junction measurements were 2.9° (SD ± 7.6) ranging from 16° of lordosis to 20° of kyphosis and 5.3° (SD ± 10.5) ranging from 10° of lordosis to 30° of kyphosis, respectively (p = 0.2467, t = 0.6943). Mean lover thoracolumbar measurements were 3.6° of lordosis (SD ± 4.1), ranging from 11° of lordosis to 2° of kyphosis and 8.1° of lordosis (SD ± 5.6), ranging from 18° of lordosis to 0° respectively (p = 0.01, t = 2.4725). Table 3.

Mean postoperative measurements of CH pattern group and RH pattern group upper thoracolumbar junction showed 4.2° of kyphosis (SD ± 4.3), ranging from 4° of lordosis to 16° of kyphosis and 6.9° of kyphosis (SD ± 3.6), ranging from 1° of lordosis to 12° of kyphosis respectively (p = 0.0445, t = 1.7643).

Table 4. Results of measurements concerning upper (T10-T12) and lower (T12-L2) thoracolumbar junction and applied hook pattern are shown. Statistical analysis (Wilcoxon signed rank test and Wilcoxon rank sum test) are shown in the last row in related cells. * and ***Difference between preoperative and postoperative T10-T12 values in both groups in not significant (p = 0.2779, t = 0.5949 and p = 0.3148, t = -7899 respectively). ** and **** Difference between preoperative and postoperative T12-L2 values is significant in both groups (p = 3.168E-04, t = -3.7639 and p = 0.036, t = -1.8994 respectively).

Hook Pattern	Preop. Sagittal contour			Relative to the preop contour			Lower instrument	
	Kyphotic	Neutral	Lordotic	Increased	Neutral	Decreased	T12	L1
Classical n:18	10 (90%)	4 (33.4%)	4 (33.3%)	16 (69.5%)	1	1 (25%)	3 (60%)	6 (46%)
Reverse n:11	1 (9%)	2 (66.6%)	8 (66.6%)	7 (30.5%)	1	3 (75%)	2 (40%)	7 (54%)
Total n:29	11	6	12	23	2	4	5	13

Table 5. Upper and lower thoracolumbar junction measurement values are given in relation to hook patterns applied. * Difference between postoperative values of classical and reverse hook patterns is significant (p = 0.0225, t = -2.268) § Difference between preoperative and postoperative values of classical hook pattern is significant (p = 0.044, t = -1.8849).

	T10 - T12		T12 - L2	
Hook pattern (Distal vertebra:L1)	Preop 3.0° ± 2.09	Postop 6.33° ± 5.28	Preop -4.33° ± 4.08 §	Postop 4.5° ± 10.73 § *
Classical n:6	(0_6°) 5.43° ± 12.57	(2°_16°) 6.71° ± 4.31	(-10°_0) -7.28° ± 5.56	(-4°_23°) -5.0° ± 2.94 *
Reverse n:7	(-10°_30°)	(1°_12°)	(-12°_0)	(-10°_0)

Mean postoperative measurements of CH pattern group and RH pattern group lower thoracolumbar junction showed 4.2° of kyphosis (SD ± 7.8), ranging from 10° of lordosis to 23° of kyphosis and 4.1° of lordosis (SD ± 4.2), ranging from 10° of lordosis to 4° of kyphosis respectively (p = 1.553E-03, t = -3.2475). There were no statistically significant difference between preoperative and postoperative measurements of upper thoracic junction in both groups (p = 0.2779, t = 05949 and p = 0.3148, t = -0.4899 respectively) and between preoperative and postoperative measurements of lower thoracic junction in RH pattern group (p = 0.036, t = -1.8994). However there was a strong significant difference between preoperative and postoperative measurements of CH pattern group (p = 3.168E-04, t = -3.7639) where mean preoperative measurement was -3.6° ± 4.1 and mean postoperative measurement 4.2° ± 7.8, respectively. Table 3.

In right thoracic, left lumbar curves 6 of the cases (60%) undergone CH pattern. The stable vertebra was L1 in 50% of the cases. Both look patterns increased T12-L2 kyphosis by 10.1° and 8.8° in CH and RH patterns respectively. Table 2. T12-L2 measurements remained lordotic or neutral in RH pattern, except in one case. Table 4.

72% of thoracic curves received classic hook pattern generally to L1 or L2. Mean increase in kyphosis was 5.6° in T12-L2 segment in CH pattern, whereas T12-L2 segment remained lordotic in RH pattern. Table 4.

There were two distal hook dislocations, one progression in curve size, and one shoulder inbalance.

DISCUSSION

Studies of Bernhardt and Bridwell (5) show that upper thoracolumbar junction Cobb measurement was 5.5° of kyphosis, ranging from 3° of lordosis 20° of kyphosis. The mean lower thoracolumbar junction

measurement was 3° of lordosis ranging from 23° of lordosis to 13° of kyphosis. As Bridwell states (6), kyphosis, especially if greater than 10° of kyphosis, is pathologic and should be considered in the instrumentation of this curve. Our results were in accord with Bernhardt and Bridwell. We found that upper thoracolumbar junction measurement was 3.8° of kyphosis, ranging from 16° of lordosis to 20° of kyphosis. Thoracal/lumbar and thoracal curves having 2.5° and 5.1° of kyphosis respectively, obeys this finding also. Lower thoracolumbar measurement was 5.3° of lordosis ranging from 18° of lordosis to 2° of kyphosis. Measurements of thoracal/lumbar and thoracal curves were 4.3° and 4.9° of lordosis Table 2. We did not observe kyphosis greater than 10° in lower thoracolumbar junction as Bridwell did.

Stable vertebra chances somehow depending on the type of the curve. Stable vertebra in thoracic curves is either L1 or L2 (most commonly L2). On the other hand, stable vertebra in thoracal/lumbar is between T11 and L1 (T12 being the most common). If selective instrumentation and fusion is performed on the thoracic curve in a skeletally immature patient, there is a risk of curve progression with age in both planes. If there is not any preexisting thoracolumbar kyphosis in lower thoracolumbar junction, there should be no problem is stopping the instrumentation at this region unless no over distraction is made. The risk of curve progression might be handled in several ways: first solution is to reverse the bend and reverse the hook orientation between the stable and neutral vertebra (10). Second solution is to stop the instrumentation one level above the stable vertebra. The third solution is to apply three rod technique and not to "derotate" the rod (6). Our findings do not support the second solution, going up one level above the stable vertebra, especially i over distraction is applied, because even if one chose higher segment, the instrumentation will still end at the lower thoracolumbar region.

When all curves are evaluated together, it is clearly seen that reverse hook pattern remained lordotic although there is a loss lordosis in seven of the cases. Table 2. Also, by using RH pattern distal level was one motion segment above when compared with CH pattern.

Lower thoracolumbar region kyphosis increased 7.8° andremained kyphotic in classical hook pattern group and a 4° increase observed in reverse hook pattern group however, the segment remained lordothic. Table 3. There was a dramatic difference between the two groups when L1 was chosen as the last instrumented vertebra. Table 4. Our results are in well accord with Shufflebarger (10).

CONCLUSION

Distraction at lower thoracolumbar region creates kyphosis. We recommend to reverse the hook pattern if the stable vertebra falls in T12-L2 region and selective instrumentation and fusion is going to be done.

REFERENCES:

1. Alıcı, E., Pınar H.: Alıcı Spinal System in the Treatment of Scoliosis. Acta Orthopaedica Belgica 58: suppl. 1:122-128, 1992.
2. Alıcı, E., Berk, H., Kırımca, M.: Alıcı Spinal System. J Bone Joint Surg 76-B suppl. 1:4, 1994.
3. Alıcı, E.,: Alıcı Spinal System. J. Turkish Spinal Surg. 2 (4): 10-24, 1991.
4. Alıcı, E., Berk, H., Özkan, M.: Alıcı Spinal System in Idiopathic Scoliosis. J. Bone Joint Surg. 76-B suppl. 1:4, 1994.
5. Bernhardt, M., Bridwell, K.H.: Segmental analysis of the sagittal plane alignment of the normal thoracic and lumbar spines and thoracolumbar junction. Spine. 14: 717-721, 1989.
6. Bridwell K.H.: Idiopathic scoliosis. In Bridwell K.H., DeWald R.L. (eds.): The Textbook of Spinal Surgery. Vol 1: 97-162, Philadelphia, JB Lippincot co., 1991.
7. Cotrel, Y., Dubousset, J., Guillaumat, M.: New universal instrumentation in spinal surgery. Clin. Orthop. 227: 10-23, 1988.
8. Jackson, R.P., McManus, A.C.: Radiographic analysis of sagittal plane alignment and balance in standing volunteers and patients with low back pain matched for age, sex, and size. Spine 19: 1611-1618, 1994.
9. King, H.A., Moe, J.H., Bradford, D.S., Winter, R.B.: The selection of fusion levels in thoracic idiopathic scoliosis. J. Bone and Joint Surg., 65-A:1302-1313, 1983.
10. Shufflebarger, H.L., Clark, C.E.: Fusion Levels and hook patterns in thoracic scoliosis with Cotrel-Dubousset instrumentation. Spine 15: 916-920, 1990.