Title: A new concept for the non-invasive treatment of Idiopathic Scoliosis: The Corrective Movement Principle.

Authors: C Coillard[1,2]
M A Leroux[2]
K F Zabjek[2]
CH Rivard[1,2]

[1] Département de Chirurgie, Faculté de Médecine, Université de Montréal. C.P. 6128 Succursale CentreVille, Montréal, Québec H3C 3J7
[2] Centre de recherche, Hôpital Sainte-Justine, 3175 ch. Côte Ste-Catherine Montréal, Québec, Canada H3T 1C5

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Centre de recherche, Hôpital Sainte-Justine
3175 ch. Côte Ste-Catherine, Montréal, Québec, Canada, H3T 1C5

Correspondence :
Dr. C-H Rivard
Centre de recherche
Hôpital Sainte-Justine
3175 ch. Côte Ste-Catherine
Montréal, Québec, Canada
H3T 1C5
Telephone : (514) 345-2344
Fax : (514) 345-4723
email : crivard@justine.umontreal.ca

ABSTRACT

The objective of this prospective study was to evaluate the acute change in spinal curvature and posture of Idiopathic Scoliosis patients when a curve specific "corrective movement principle" (CMP) is applied. A total of 113 patients diagnosed with progressive Idiopathic Scoliosis underwent a comprehensive evaluation (clinical, radiological, and postural geometry) prior to and following the application of the CMP. The principle radiological parameters included the Cobb angle for the estimation of the degree of spinal curvature in the frontal and the sagittal planes. The postural geometry evaluation was used to quantify the position and the orientation of the pelvis, shoulders and thorax. These two evaluations assisted to define the patient classification, which guided the unique application of the CMP to each type of curvature. A non-rigid brace (SpineCor©) was used to favorise the CMP, and a second comprehensive evaluation was performed to evaluate the spinal and postural changes induced by the CMP. There was a significant decrease in the frontal plane Cobb angle with the brace induced CMP. This decrease in spinal curvature was also accompanied by curve specific postural changes to the tilt, rotation, and shift of the pelvis, shoulders and thorax. These postural changes reflect the unique CMP that was used for each type of scoliosis curvature. The results of this study indicate that it is possible to acutely decrease a scoliosis curvature using a treatment technique that is based on the CMP. The results of this study serve the basis for the development of a treatment approach for the treatment of patients with Idiopathic Scoliosis.

KEY WORDS: Orthopaedics, Posture, Idiopathic Scoliosis, Biomechanics, Pediatrics

INTRODUCTION

The prevalence of Idiopathic Scoliosis (IS) is estimated to range from 2-4% of the population [5,26]. The principle characteristic of IS is the torsion and deviation of the spine in the frontal plane which is accompanied by individual vertebral deformity [27] and disorientation [24]. In addition, the unique segmental specific vertebral morphology [17,25] and mobility, [25] as well as the risk factors such as growth [13] complicate the precise definition of the pathomechanics of disease progression and the definition of an optimal treatment approach.

The material and forms of external rigid bracing systems has changed considerably over the years with numerous techniques utilised [16, 25]. However, the underlying treatment principles have not changed. These principles include traction and a lateral force applied to the trunk resembling the three-point pressure principle [15]. The initial reducibility of scoliosis curves based on this approach has been found to range from 50 to 62 percent of the initial spinal curvature [9,19]. This reducibility is gradually lost during growth and development of the adolescent with definite limitations in maintaining the reduction after weaning [9,19]. There are also a number of patients who ultimately progress to surgery [9,19]. Surgical treatment has been found to stabilise and reduce the scoliosis curve [20, 8]. However, the negative consequences such as the risk for revision [10, 11] and decreased mobility [4] has led to the acceptance of rigid brace treatment as a viable means to reduce and stabilise spinal curvatures [9, 22].

There are several limitations of the current bracing techniques. These include the principal of the three-point pressure approach, which is the assumption that the same principal of force application (amplitude and direction) can be used at different spinal levels. The efficacy of these forces that are applied through the bracing systems [1,2] has been questioned.

The unique morphology (skeletal and muscular) and mobility of each spinal level [25] suggests that a treatment approach that functions in accordance to these characteristics warrants further attention. Therefore, in this study, a curve specific ‘’corrective movement principle’’ (CMP) is proposed. The objective is to describe the mechanisms that are behind this principle and quantify the induced change in spinal curvature and posture of Idiopathic Scoliosis patients when the ‘’corrective movement principal’’ is applied.

Material and Methods

Patients

Between 1995 and 2000, 113 patients, 100 girls and 13 boys, were included in this study. These patients attended the Spinal Pathology Evaluation Centre at Sainte-Justine Hospital and were evaluated for the follow-up of their orthopaedic spinal problem. Primary inclusion criteria included: 1) Confirmed diagnosis of Idiopathic Scoliosis with normal clinical neuromuscular exam; 2) Initial Cobb angle equal or superior to 15°; 3) A proven evolution of 5° or more within the last year and/or a high potential risk of evolution. 4) No prior treatment (e.g. rigid brace) for their IS, with the exception of physiotherapy.

Evaluation Protocol

Each Idiopathic Scoliosis patient underwent a comprehensive evaluation. This included an anthropometrical, clinical, radiological and postural geometry examination. The anthropometrical evaluation involved the palpation of surface anatomical landmark's that served as markers for the clinical and postural geometry evaluations. The clinical exam involved both subjective observations of the patients posture (static and dynamic), as well as the evaluation of the history of the patient.

The radiological exam of the patient was performed using a numeric radiographic technique where the radiation of the patient is reduced by 62% [23] of standard radiographic techniques. A posterior-anterior radiograph of the spine was taken with the superior limit being the cervical region and the inferior limit the inferior aspect of the pelvis. A sagittal radiograph of the spine was obtained at the same level providing a right lateral view of the patient. The apex and side of the spinal convexity defined the type of curvature. The amplitude of spinal deformity in the frontal plane, kyphosis and lordosis, were measured using the Cobb angle technique [6].

The postural geometry evaluation was performed using a Motion Analysis system. This system consisted of 8 high-speed video cameras connected to a video processing unit and computer. The locations of the cameras were arranged such that there was a full anterior and posterior view of the patient with a minimum of 2 cameras viewing each individual anatomical landmark. The patient was evaluated in a quiet standing position with the arms slightly abducted. The technique used to calculate the postural parameters is the same as that reported previously [7,3]. The angular measurements are positive when counter-clockwise as seen from posterior (Tilt) and apical (Rotation) views. The linear measurements (Lateral shift) are positive going to the left of the patient.

These evaluations served to define the amplitude and severity of the spinal curvature, the type of spinal curvature as well as additional postural characteristics unique to each type of curvature. This was followed by the definition and application on the patient of the curve specific ''corrective movement principal" (CMP) (Figure 1) by the attending physician. A non-rigid brace (SpineCore©) was used to favorise the CMP on the patient. (Figure 2) This non-rigid brace is composed of a pelvis base and a bolero fitted to the upper trunk as an anchor to manipulate the orientation of the pelvis, thorax and shoulders through the use of four elastic bands. The brace was fitted to favorise the CMP in order to evaluate the induced changes on the spine and posture.

The Corrective Movement Principle (CMP)

The CMP evaluated in this study is based on the unique kinematics of the thoracic, thoracolumbar and lumbar segments of the spine. The amplitude and direction of these kinematics is defined by the shape of the vertebra, the geometry of its articular facets, the spinous processes and the presence or absence of rib articulations. Soft tissues such as muscles and ligaments also control, and limit actively or passively, the amplitude of the movement depending on the orientation of their vector of origin and insertion.

The mobility of the thoracic spine, from T1 down to T11, is directed not only by the orientation of the zygapophyseal facets in the frontal plane, but also by its articulation with the ribs, and muscle action. The thoracic segment shows relatively important segmental motion in the transverse plane, with small amplitudes of flexion/extension [25]. In the thoracolumbar region, the joints with the rib cage are less constraining and the orientations of the facets are directed progressively in a sagittal direction. As a result, this segment could produce large movements in the frontal plane, some coupled movements in the sagittal plane, but very little in the transverse plane. The shape of the lumbar vertebrae is very specific with facets in a complete sagittal plane. This segment could produce very large amplitudes of flexion/extension but little lateral bending and almost no rotation.

Since the movement amplitude of the thoracic spine is larger in torsion, the corrective movement should also be planned to occur in this direction. The correction of a right thoracic curve should then include a de-torsion of the thorax relative to the shoulder girdle (Figure 1). The shoulder girdle should be rotated to a neutral position or, if possible, progressively into a clockwise rotation. The corrective movement is then obtained by rotating the thorax in a counter-clockwise direction relative to the shoulders (A, B). This action will also prevent the shoulder rotation from being absorbed by the thoracolumbar or lumbar segment of the spine. This movement represents a de-torsion between the vertebral segments over and under the apex, associated with coupled movements in the frontal and sagittal plane. They then reach an improved alignment with the vertebrae involved in the scoliosis. The corrective movement is also accomplished with a slight down tilt of the right shoulder (A). The right lateral shift of T1 in relation to S1 should consequently be reduced (C). This combination of movements should result in the straightening of the spine.

In the thoracolumbar region (T11, T12 and L1), the movement of greater amplitude is the lateral bending. Thus the corrective movement includes a change in the bending of the trunk in the frontal plane. For a left thoracolumbar curve, it goes from a clockwise to a counter-clockwise bending of the trunk in reference to the pelvis. The right thoracolumbar curves require the opposite movement. To account for the frequent pelvis tilt of these patients, the use of a shoe lift should also be considered. This horizontalisation of S1 will then accentuate the desired action of the corrective movement in the frontal plane.

In the lumbar region under L1, the main permissible movement is the flexion/extension in the sagittal plane. However, this action is also closely associated with the natural “C” shape configuration of the natural lordosis. However, its close location relative with the pelvis that represents a strong base, should allow some alternative strategy. The corrective movement is then designed principally to occur in the frontal and the sagittal plane. It includes a right shift of the trunk relative to the pelvis, combined with a lateral inclination of the trunk to the left. This produces an extension of the lumbar vertebrae by bringing them into the direction of their natural position.

Since the double curvatures cover all segments of the spine, a specific plane of mobility could not be used. For these patients, the corkscrew shape of the spine represents the geometry to change. In these cases, the principal corrective movement includes torsion of the shoulders relative to the pelvis around a longitudinal axis. This specific spine shape should not be seen as a combination of two curves. The kinematics involved is different and is reflected by a specific postural geometry.

Statistical Analysis

Data analysis included descriptive statistics as well as two-way analysis of variance (ANOVA) for repeated measures: the two factors were 1) curve type, with four levels: Thoracic (Th), Thoracolumbar (ThL), Lumbar (L) and Doubles (D), and 2) the repeated factor TIME, with two levels: initial status and the brace induced corrective movement principal (BMCMP) condition. In the presence of an interaction effect, simple main effects were calculated to identify between group differences at the initial and the BMCMP condition, and change over time for the four groups. When appropriate, Sidak post hoc multiple comparisons procedure was used to locate between-groups differences. A .05 alpha level was used for all analyses.

RESULTS

Initial Radiological Characteristics of the Idiopathic Scoliosis Patients.

The mean age at the initiation of treatment was 13 years, Standard Deviation (SD) 1 year. Most of the patients (69), showed a Risser sign of 0, 13 patients were at Risser 1, 9 patients at Risser 2, 18 patients at Risser 3, and 2 patients at Risser 4. The patients were classified as 43 thoracic curves, 45 thoracolumbar, 8 lumbar and 17 double curves. The initial radiological characteristics for each type of curvature are presented in Table 1.

Radiological Differences Between Groups and Changes Induced by the Corrective Movement Principal.

The radiological and postural characteristics of the four classes of patients prior to and following the application of the CMP are presented in Table 2. For the Cobb angle, the ANOVA revealed a significant interaction effect. Between group pairwise comparisons identified a significant difference between the Thoracic and Thoracolumbar patients (p=0.034) at the initial condition. The simple main effects revealed that regardless of the classes, the brace induced CMP condition was significantly lower than the initial condition (P<0.01). After the application of the brace induced CMP the mean reducibility was 28% (SD: 18) for the thoracic, 38% (SD: 21) for the Thoracolumbar, 32% (SD: 11) for the Lumbar and 21% (SD: 22) for the Double curves. At the BMCMP condition there was a difference between the Double and Thoracolumbar (p=0.005) and Thoracic and Thoracolumbar (p = 0.002) groups.

Initial Postural Differences Between Groups

The ANOVA identified a significant main effect for time and for group. ($p<0.05$) for two postural parameters. These two parameters were the rotation of the shoulders and rotation of the scapula in reference to the pelvis. A pairwise comparison between groups revealed a significant difference between the Thoracic and Thoracolumbar patients for the rotation of the shoulders (mean : 3°; Confidence Interval (CI): .9° to 4.8°). For the rotation of the scapula in reference to the pelvis a difference was found between the Double curves versus the Thoracic (mean:-3.0°;CI: -6.1° to 0°), Thoracolumbar (mean:-6.7°;CI: -9.7° to –3.6°) and Lumbar curves (mean:-7.5°;CI: -12.1° to –2.9°), and a significant difference between the Thoracic versus the Lumbar and (mean:4.5°;CI: 0.4° to 8.5°) Thoracolumbar curves (mean:-3.6°;CI: -5.8° to –1.5°).

For the parameters where there was an interaction effect post-hoc pairwise comparisons were performed to identify postural differences between groups at the initial status (See Table 2). The Thoracic patients were different to the Lumbar and Thoracolumbar patients for a number of parameters. These patients had a characteristic counter-clockwise rotation in the transverse plane for the shoulder girdle (CI: 3.0° to 5.2°), an opposite clock-wise rotation of the scapula (CI: -6.5° to –3.5°) and a right lateral shift of the shoulders in reference to the pelvis (CI: -5.9mm to 2.2mm). The patients with a Double curvature were mostly characterised by a clock-wise rotation of the scapula in reference to the pelvis (CI: -6.8° to –3.5°) and counter-clockwise rotation of the shoulders (CI: 0.5° to 6.2°) in reference to the pelvis in the transverse plane. For the Thoracolumbar patients the principal postural characteristics are most evident in the frontal plane, which included a counter-clockwise tilt of the pelvis (CI: 0.7°

to 2.0°) and a clock-wise tilt of the shoulders in reference to the pelvis (CI: -3.2° to 0.6°). For the lumbar patients, the major postural characteristics are also in the frontal plane. This includes a shift to the left of the shoulder girdle in relation to the pelvis (CI: 7.2mm to 27.1mm), with the presence of a counter-clockwise pelvic tilt in some patients (CI: 0.5° to 4.4°).

Changes Induced by the Corrective Movement Principal for the Thoracic Patients

The corrective movement for the Right Thoracic patients was characterised by a clock-wise change (Initial - BMCMP condition) in the tilt (mean: 0.7°;CI: .1° to 1.3°) and counter-clockwise rotation (mean: -2.5°; CI: -3.8° to -1.2°) of the pelvis. There was a clock-wise change in tilt of the shoulders (mean : 1.3°; CI: 0.7° to 1.9°), clock-wise rotation of the shoulders in reference to the pelvis (mean: 6.5°; CI : 4.5° to 8.5°), clock-wise rotation of the shoulders in reference to the scapula (mean: 3.7°; CI : 2.5° to 4.9°). There was a change in the left lateral shift of the shoulders (mean: -5.8°; CI: -9.6° to –1.9°), and left lateral shift of the shoulders in reference to the pelvis (mean: -10mm; CI -13mm to –7mm). This postural reorganisation was accompanied by a mean 8° decrease of the Cobb angle (CI : 7° to 9°). Figure 3 presents the posture in the frontal and apical views of a typical Right Thoracic patient before and after the application of the corrective movement principle.

Changes Induced by the Corrective Movement Principal for the Thoracolumbar Patients

For the thoracolumbar patients, the mean postural changes for the thoracolumbar patients are represented by a counter-clockwise change in tilt of the shoulders (mean : -1°; CI: -1.6° to -0.4°), clock-wise rotation of the scapula (mean: 2.8°; CI : 1.5° to 4.1°) and clock-wise rotation of the shoulders in reference to the pelvis (mean: 3.0°; CI : 1.0° to 4.9°). These postural changes were accompanied by a mean change in the Cobb angle by 10° with a CI of 8° to 11°. Figure 4 presents the posture in the frontal and apical views of a typical Left Thoracolumbar patient before and after the application of the corrective movement principle.

Changes Induced by the Corrective Movement Principal for the Lumbar Patients

For the lumbar patients, there was a counter-clock-wise change in the tilt of the shoulders (mean: -1.7°; CI: -3.2° to –2. This was accompanied by a decrease in the degree of the lumbar spinal curvature of 7° with a CI of 6° to 8°. Figure 5presents the posture in the frontal and apical views of a typical Left Lumbar patient before and after the application of the corrective movement principle.

Changes Induced by the Corrective Movement Principal for the Double Patients

For the patients with a double curvature, there was a counter-clockwise change in the rotation of the pelvis (mean: -4.5°; CI : -6.9° to –2.3°), clock-wise tilt of the shoulders (mean: 1.6°; CI: 0.5° to 2.8°), clock-wise rotation (mean : 9.2°; CI : 5.6° to 12.8°) and clock-wise tilt of the shoulders in relation to the pelvis (mean: 2.1° (CI :.5° to 3.7°), clock-wise rotation of the shoulders in reference to the scapula (mean: 4.8°; CI :2.6° to 7.0°) and left lateral shift of T1 in reference to S1 (mean: -8.4 mm; CI : -14 to -3mm). There was a mean decrease in the Cobb angle of 6° with a CI of 3° to 10° for the thoracic curve and a mean decrease of 8° with a CI of 3° to 14° for the lumbar and thoracolumbar curves. Figure 6 presents the posture in the frontal and apical views of a typical Right Thoracic Left Lumbar patient before and after the application of the corrective movement principle.

Postural Differences Between Groups at the BMCMP Condition.

The significant differences identified between groups at the BMCMP condition are also reported in Table 2. These differences reflect the unique postural position that results from the BMCMP for each type of curvature. The principal differences were identified between the Thoracic versus the Thoracolumbar and Lumbar patients for the tilt of the shoulders, and rotation of the shoulders in reference to the scapula. Between the Thoracic, and Double versus the Thoracolumbar patients for the rotation of the scapula. Between the Thoracic versus the Lumbar for the lateral shift of the shoulders and between the Double versus the Thoracic patients for the rotation of the shoulders in reference to the pelvis and the lateral shift of the shoulders in reference to the pelvis. The Thoracic patients were also different from the Thoracolumbar patients for the lateral shift of the shoulders in reference to the pelvis.

DISCUSSION

The objective of this article was to evaluate the acute change of an Idiopathic Scoliotic curve and posture that may be induced by the application of the CMP. Within the context of this article the term CMP is used to define the manner in which this spinal change may be achieved. The corrective movement principal involved inducing a change to the initial posture of the patient. The application of this movement is dependent upon the initial state of the patient, as well as the complex interaction of soft tissue, coupled vertebral movements and the morphological characteristics of each vertebra. The effectiveness of this movement does not necessarily imply the application of large external forces, but optimal forces applied in an optimal direction for each type of scoliosis curvature. When the patients were divided into groups according to the classification of idiopathic scoliosis, there were specific postural characteristics identified with each type of scoliosis curvature. The principal plane in which these characteristics were located was specific to each class of patient. This included the apical view for the thoracic and double curve patients, and the frontal view for the thoracolumbar and lumbar patients. The nature of these differences between each type of curve is principally related to the mobility of each spinal segment and the different muscular attachments and actions at each spinal level. The corrective movement principal was conceived to function with respect to the unique skeletal morphology and muscular characteristics. When the patients were prescribed with the corrective movement principal, and the spinal bracing system was fitted to induce this principal, there was a significant decrease in the degree of spinal curvature for all of the patients. This change in spinal curvature was accompanied by a significant change in the patients' posture. These postural changes were specific to each type of scoliosis curve, reflecting the unique corrective movement sought after for each patient. For the thoracic patients these changes involved the opposite rotation of the shoulder girdle in reference to the thorax accompanied by a coupled movement of shoulder tilt and lateral shift of T1 in reference to S1. For the thoracolumbar patients there was also a change in the relative rotation of the shoulders in reference to the pelvis, the tilt of the shoulders and tilt of the shoulders in reference to the pelvis. Although there was a relatively small number of lumbar patients, they showed a tendency for a tilt of the shoulders. The patients with a double curvature had a significant change of the shoulders in reference to the pelvis in the transverse plane. With these postural changes, it is important to note that there was not a realignment of the patients' posture to a completely normal position. Also, the in-brace posture was not consistent across all of the patients with a similar type of curvature, which underlines the unique degree of mobility for each patient. This indicates that the mechanism sought to correct the spinal deformity with the brace, is not a normalisation process, but a postural change that will lead to a correction of the spine. It is also a mechanism that is dependant on, and specific to, the unique mobility of each spinal level, the flexibility of the patient's posture, and the adaptability of the musculoskeletal system.

To effectively apply and evaluate the changes induced by the CMP, a three dimensional postural evaluation technique was chosen to evaluate the position and orientation of the pelvis, thorax and shoulder girdle [7]. Since this technique is three dimensional, it completes the perspective on the spine providing a more comprehensive evaluation of the patient. The utilisation of surface anatomical landmarks as points of reference is the basis of this evaluation. This permits a characterisation of the net geometrical configuration of idiopathic scoliosis patient posture as well as changes that occur in conjunction with a spinal correction [3,7,18]. The initial postural change induced by the CMP was then induced and favoured by a flexible bracing system (SpineCore©), providing the patient with a guided degree of mobility, that would favour a spinal correction. This system is composed of flexible elastic bands, and a bolero and pelvic base to act as anchoring points. Depending upon the initial state of the patient, the amplitude of the forces created by the tension of each corrective band will depend upon the two points of attachment. The length of the bands as well as the inherent tension of each band will change in conjunction with the patients' growth and change in body flexibility. However, the direction and point of force application for each type of scoliosis curve should not change through the course of treatment. This emphasises the point that for a specific type of scoliosis curve, the corrective movement does not change through the course of treatment.

The treatment approach that is used here is different than that utilised using rigid bracing systems. The principal mechanics associated with the reduction and stabilisation of idiopathic scoliosis curves using rigid braces involves the application of distraction and a three-point pressure approach. The efficacy of the rigid brace treatment approaches has been questioned through a biomechanical analysis [1,2]. These factors reflect the non-specificity of rigid brace treatment, where there is no account for the segmental specific anatomy and mobility of the spine. The corrective movement which is favoured using the SpineCor brace allows the opportunity to focus treatment on each specific spinal level, implicating a different action necessary for each curve type. The number of different braces that are available to treat idiopathic scoliosis reflects this. Due to the nature of the corrective movement and the SpineCor brace, a direct comparison to biomechanical analysis of rigid bracing performed in the literature cannot be made within the context of this article. The corrective movement involves a coupled movement induced by a number of elastic bands. The amplitude of force required for each patient will be different, as well as the initial reducibility and flexibility of each patient. Principles of the orthopaedic approach applied to the idiopathic scoliosis patients of this study are similar to that applied to the Pavlik harness for congenital hip dislocation of infants. This principle is based on the optimal definition of a movement that will favour correction, normal growth and development and discourage aggravating movements to the pathology [12,14,21]. The optimal efficacy of this treatment is reported to be dependent on the early commencement of treatment, as well as good patient compliance [14].

The effectiveness of the CMP in changing the spinal curvature of IS patients in this study forms the basis for the application of this treatment principle with the objective of altering the natural history of the pathology.

Treatment with the CMP would involve the early initiation of treatment, before the patient commences rapid growth and curve structuralisation to benefit from the important mobility of the spine at the early stage of the pathology. The relative simplicity in adapting the brace to the growth of the patient, as well as changes in mobility and flexibility facilitates adaptation of the treatment approach. The control of spine mobility during growth should limit the impact of the aggravating factors and teach the system to work properly in these modified conditions. Positive long-term result should then be expected.

CONCLUSION

The ‘’corrective movement principal” outlined in this study demonstrates an initial ability to decrease the amplitude of spinal curvature in Idiopathic Scoliosis patients. The postural changes that were quantified when the “corrective movement principal” was applied reflects the unique action required for each type of Idiopathic Scoliosis curvature. The amplitude of these changes support the basis for the evaluation of the long term efficacy of this treatment approach.

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LEGENDS TO FIGURES

Figure 1: Corrective movement principal demonstrated on a right thoracic patient.

Figure 2 : The corrective movement principal favorised by the SpineCor system.

Figure 3 : Apical and Posterior-Anterior view of a typical Right Thoracic patient, without the BMCMP and with the BMCMP. Note that due to the brace the thorax could not be defined in the right graph.

Figure 4 : Apical and Posterior-Anterior view of a typical Left Thoracolumbar patient, without the BMCMP and with the BMCMP.

Figure 5 : Apical and Posterior-Anterior view of a typical Left Lumbar patient, without the BMCMP and with the BMCMP.

Figure 6 : Apical and Posterior-Anterior view of a typical Double curve patient, without the BMCMP and with the BMCMP. Note that due to the brace the thorax could not be defined in the right graph.

LEGENDS TO FIGURES

Figure 1: Corrective movement principal demonstrated on a right thoracic patient.

Figure 2 : The corrective movement principal favorised by the SpineCor system.

Figure 3 : Apical and Posterior-Anterior view of a typical Right Thoracic patient, without the BMCMP and with the BMCMP. Note that due to the brace the thorax could not be defined in the right graph.

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Fig. 1

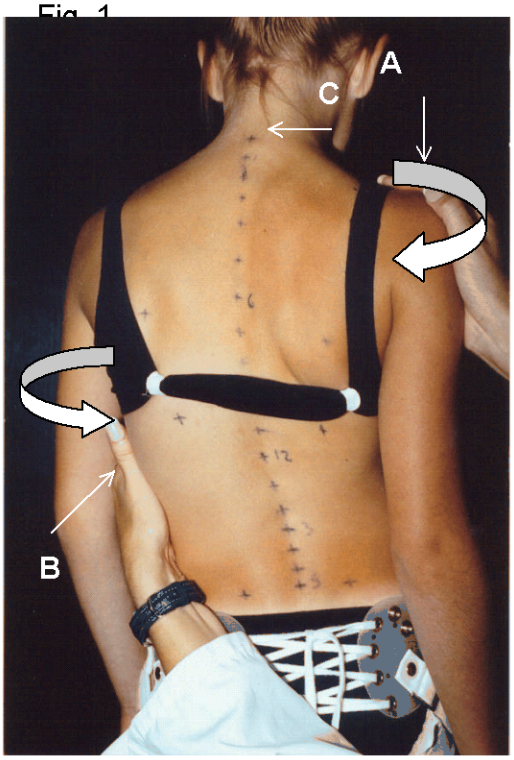


Fig. 2

Figure 3 :

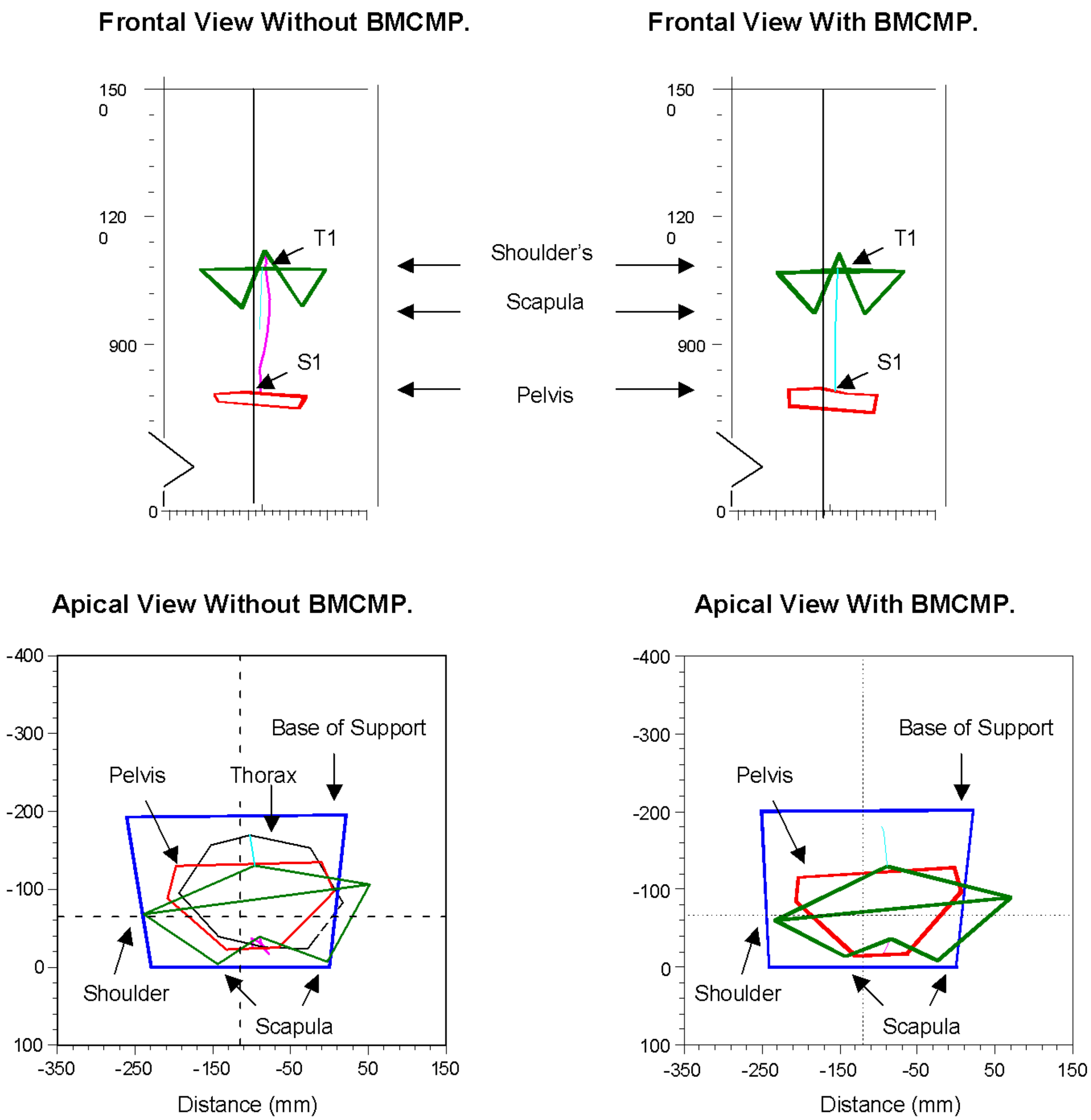

Frontal View Without BMCMP.
Frontal View With BMCMP.
150
0
120
0
900
0
T1
S1
Shoulder's
Scapula
Pelvis
Apical View Without BMCMP.
Apical View With BMCMP.
-400
-300
-200
-100
0
100
-350
-250
-150
-50
50
150
Distance (mm)
Base of Support
Pelvis
Thorax
Shoulder
Scapula

Figure 4 :

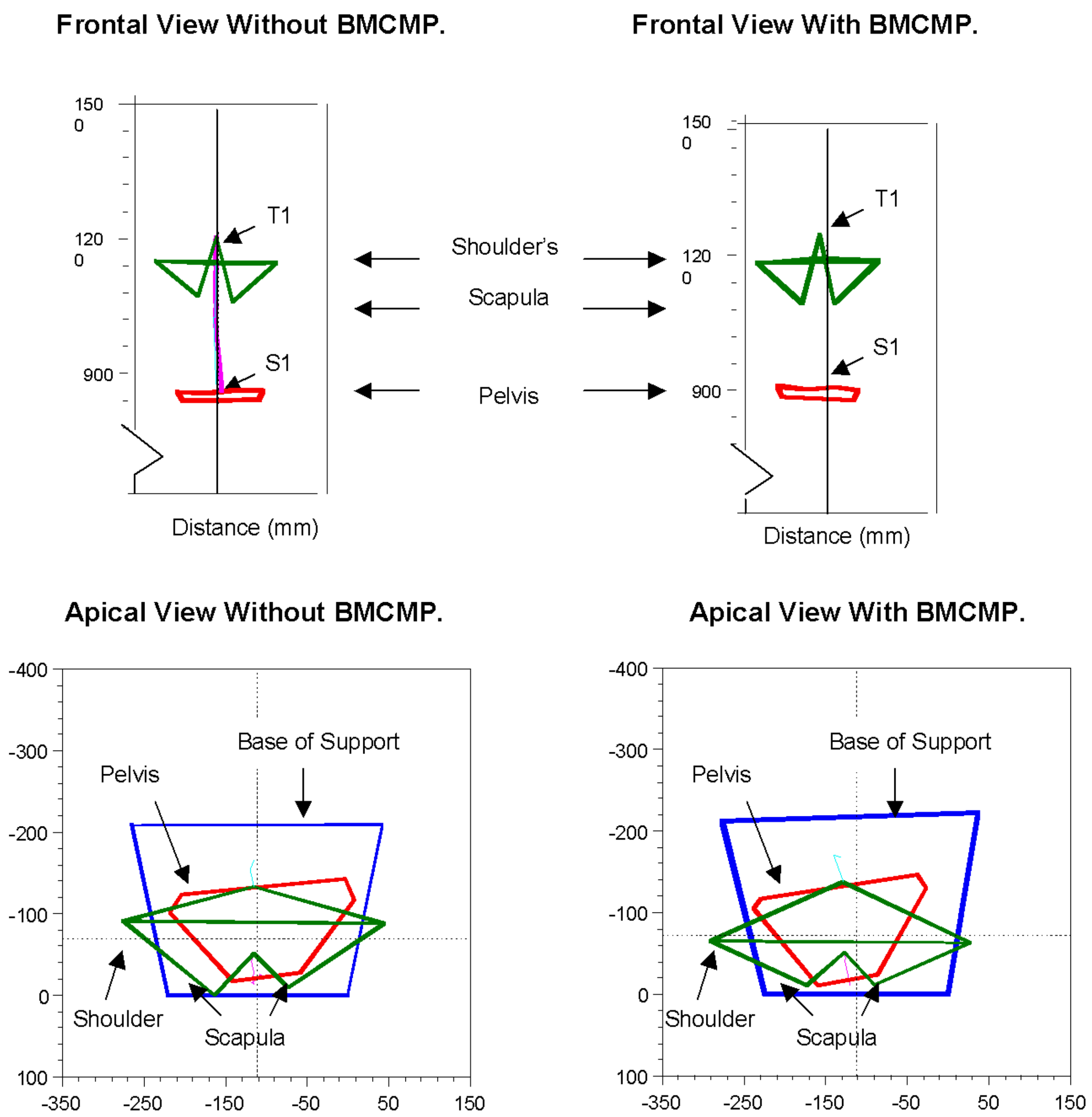
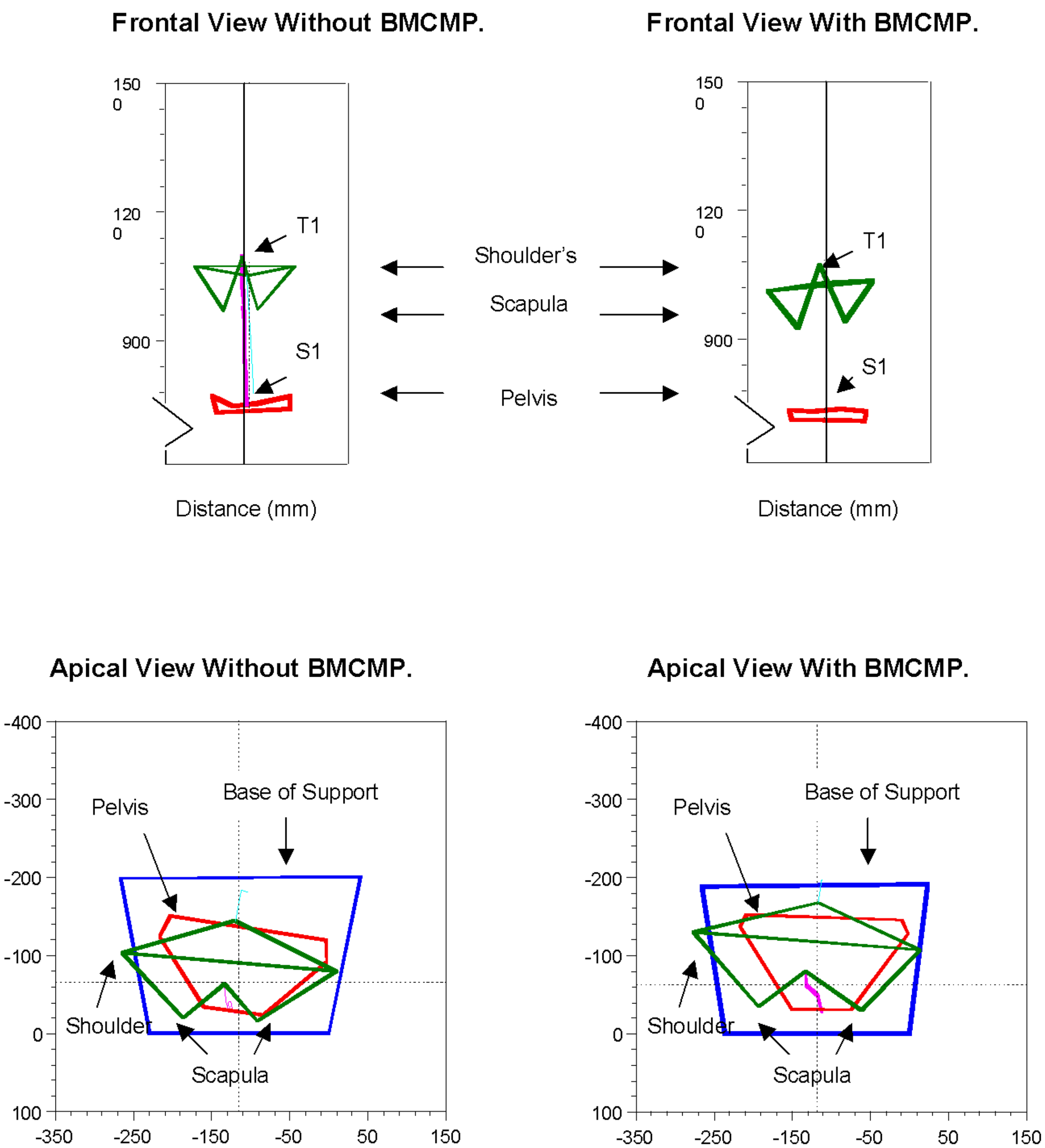
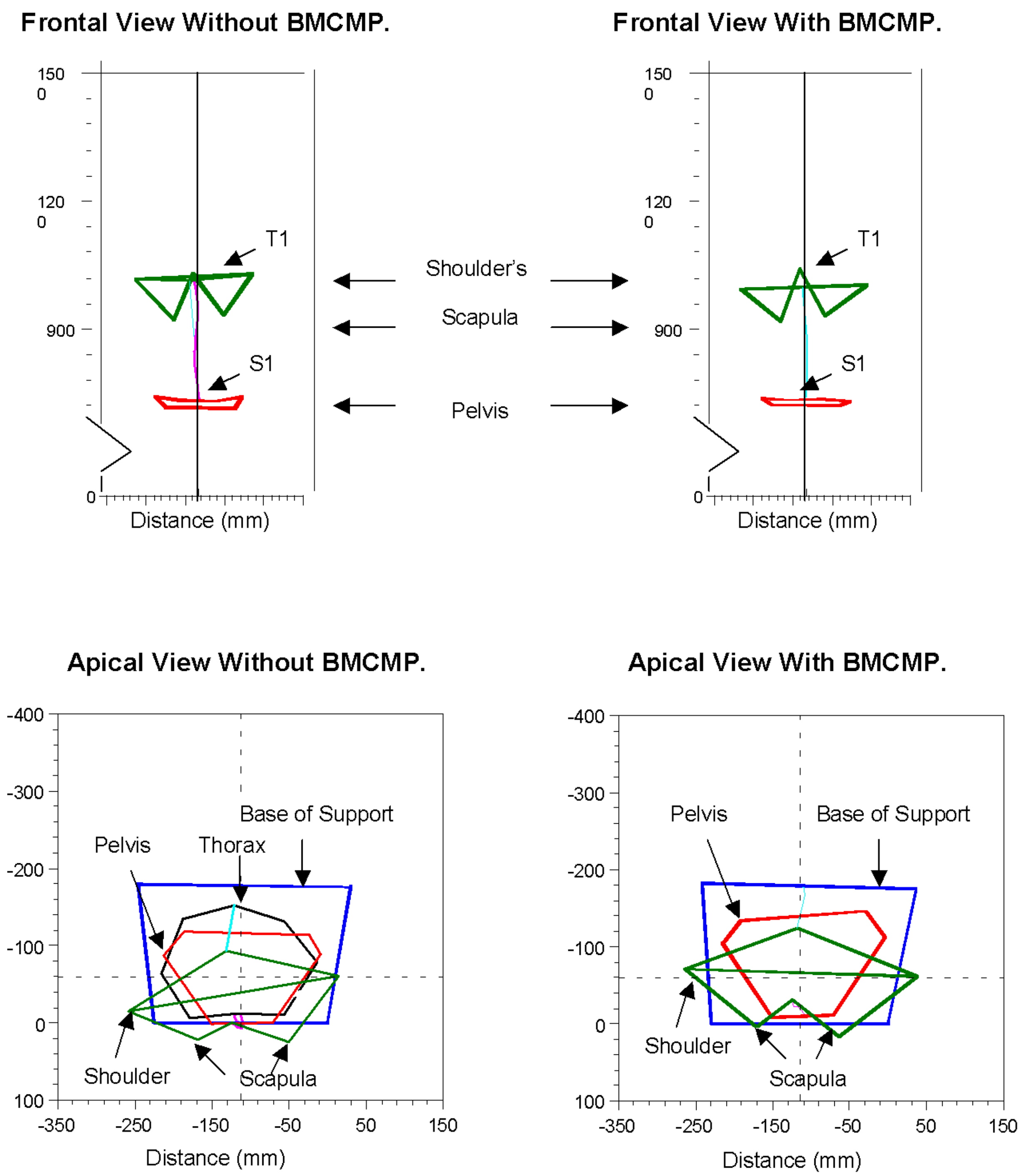

Frontal View Without BMCMP.
Frontal View With BMCMP.
150
0
120
0
900
T1
S1
Shoulder's
Scapula
Pelvis
Distance (mm)
Apical View Without BMCMP.
Apical View With BMCMP.
-400
-300
-200
-100
0
100
-350
-250
-150
-50
50
150
Base of Support
Pelvis
Shoulder
Scapula

Figure 5 :



Frontal View Without BMCMP.
Frontal View With BMCMP.
150
0
120
0
900
T1
S1
Shoulder's
Scapula
Pelvis
Distance (mm)
Distance (mm)
Apical View Without BMCMP.
Apical View With BMCMP.
-400
-300
-200
-100
0
100
-350
-250
-150
-50
50
150
Pelvis
Base of Support
Shoulder
Scapula

Figure 6 :


Frontal View Without BMCMP.
Frontal View With BMCMP.
150
0
120
0
900
0
T1
S1
Shoulder's
Scapula
Pelvis
Distance (mm)
Apical View Without BMCMP.
Apical View With BMCMP.
-400
-300
-200
-100
0
100
-350
-250
-150
-50
50
150
Base of Support
Pelvis
Thorax
Shoulder
Scapula
Distance (mm)