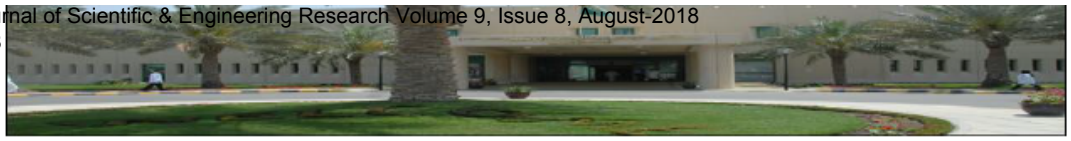

The effectiveness of spinal bracing and different types of bracing on Idiopathic Scoliosis (Mini simple clinical review)

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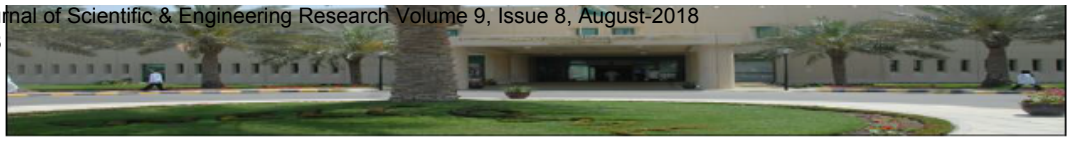
Abstract: Spinal bracing is effective in all age group patients and it is almost indicated to every patient who has a degree of curving depending on the severity and time the patient diagnosed during his/her growth. Bracing is paramount in improving the patient condition, it ameliorate the pain and it decreases the speed of disease progression.
The end result of brace treatment is dependent on the extent of the disease and either corrected completely or partially and also depends on the patient compliance to the treatment. Our aim was to analyze and review the articles and literatures on spinal bracing to locate and familiarize ourselves with the types of braces and the effectiveness of each type accordingly.

Materials and Methods: The literature has searched for papers on bracing types and effectiveness of each type and long-term outcomes.

Results: According to our data, which has collected, we have found that the early detection of scoliosis on the patient the better results was seen with bracing. Moreover, the early starting of treatment is the best option for patients with scoliosis, which end up with the best outcomes. Nevertheless, There are several types of braces available these braces have different biomechanical corrective principles, with varying effectiveness in halting progression of curvatures.

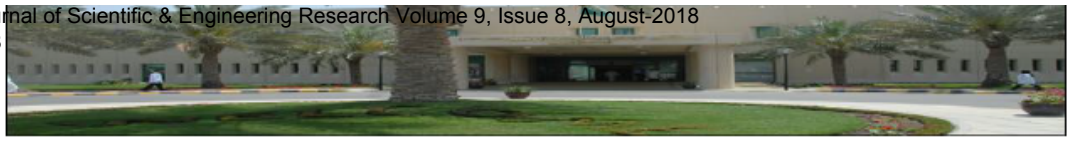
Conclusion: Wearing a spinal brace improved postural stability in terms of increased proprioception, equilibrium performance, and rhythmic movement ability in patients with AIS, however, clinical outcomes following treatment of idiopathic scoliosis are strongly linked to curve magnitude.



Introduction:

Idiopathic Scoliosis nowadays is considered as one of the deformities seen frequently in different age groups and in different sexes [1]. In the past, terminology such as kyphoscoliosis was inappropriately used to describe certain patients with idiopathic scoliosis [1-3]. Idiopathic scoliosis has a strong tendency to flatten the normal kyphosis of the thoracic spine. To define scoliosis it is a three dimensional deformity of the spine and trunk, which hinder and deteriorate quickly during phases of Increased growth velocity [4, 5]. Idiopathic scoliosis (70%–80% of cases), the causes are unknown. [2] Adolescent idiopathic scoliosis (AIS) is discovered at 10 years of age or older,[3] and is defined as a curve of at least 10°, measured on a standing radiograph using the Cobb technique.[2] Although the prevalence of AIS is 0.9% to 12% in the general population, almost 10% of those diagnosed with AIS will require some form of treatment. Furthermore, up to 0.1% of the population is at risk of surgery.[1,4] A severe form of AIS is more commonly found in women. Typically, AIS does not cause any health problems during growth (except for extreme cases). However, the resulting surface deformity frequently has a negative impact on adolescents, which can give rise to quality of life (QOL) and, in the worst cases, psychological disturbances.[5–8] Adolescent patients are generally treated in an attempt to halt the progressive nature of the deformity. No treatments succeed in full correction to a normal spine, and even reduction of the deformity is difficult. [4,9] If scoliosis surpasses a critical threshold, usually considered to be 30° Cobb at the end of growth the risk of health problems in adulthood increases significantly.[4,10] Problems include reduced quality of life (QOL), disability, pain, increased cosmetic deformity, functional limitations, pulmonary problems sometimes, and possible progression during adulthood.[9–16] Because of this, management of scoliosis also includes the prevention of secondary problems associated with the deformity.[17–19]
Nowadays, there are two main routes for treatment of scoliosis, surgical treatment and conservative treatment; in our study we will discuss the conservative treatment of scoliosis. However, bracing currently is the most preferred option for many patients because it is not invasive and less costly [6, 7]. There are at present several types of braces on the market; there are symmetrical and asymmetrical braces, rigid and soft braces, full time braces and nighttime braces [7, 8]. These braces have different biomechanical corrective principles, with varying effectiveness in halting progression of curvatures. [8-10].

Materials and Methods: PubMed was searched, using key words “brace” and “adolescent idiopathic scoliosis”, and “effectiveness”. We have chosen 7 clinical trails articles and 2 review articles. We excluded studies that deal with management options of surgery and we excluded nighttime spinal braces and excluded any articles other than English language. Also, we excluded articles that do not have in-brace correction or success rate as outcome measures. We included studies on the effectiveness of all types of full time spinal braces, rigid or flexible, symmetrical or asymmetrical. Moreover, we have included all the patients with different age groups and different sexes. Further, we searched on spinal orthoses, especially when compared to hand made braces. Research on brace compliance is also reviewed. Participant descriptive data, baseline Cobb angle, the type of braces used and outcome are extracted from these studies for comparison and review.



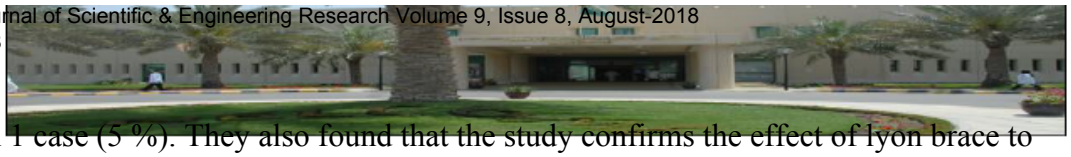
Results:

Study 1: Stefano Negrini et al evaluated the efficacy of bracing in adolescent patients with adolescent idiopathic scoliosis (AIS). They included 2 studies. They found that there was very low quality evidence from 1 prospective cohort study with 286 girls that a brace curbed curve progression at the end of growth (success rate, 74% [95% confidence interval {CI}:52%–84%]), better than observation (success rate, 34% [95% CI: 16%–49%]) and electrical stimulation (success rate, 33% [95% CI: 12%–60%]). There is low-quality evidence from 1 RCT with 43 girls that a rigid brace is more successful than an elastic one (SpineCor) at curbing curve progression when measured in Cobb degrees, but there were no significant differences between the 2 groups in the subjective perception of daily difficulties associated with wearing the brace.

Study 2: Philippe Mahaudens et al their objective was First, to valuate the ideal short-term changes in radiological and gait parameters with and without brace. Second, to compare the gait variables changes between braced AIS patients and healthy individuals. That will confirm if the brace will lead to more stiffened gait AIS patient than the other group. Third, to compare the two braced groups if they have similar changes in the gait parameters. Philippe Mahaudens found that TLSO brace wearing in short-term reduces the main structural curve by 34% of thoracolumbar/lumbar AIS patients. However, the braced AIS patients has been provided a more restricted frontal and pelvis motion compared to healthy individuals. There weren't significant changes of EMG activity of lumbo-pelvic muscles, mechanical and energetic consumption during gait. Nevertheless, the brace timing activity of Gluteus Medius muscle bilaterally were decreased in AIS patients and increased in healthy individuals.

Study 3: Rachel M. Thompson et al their aim was to Report the effectiveness of curve morphology on the response to bracing with a thoracolubosacral orthosis (TLSO). 168 patients were included in the study. There was a predominance of solitary main thoracic curves. At the time of brace initiation, 84 of patients (50.0%) had curves which classified as mLenke type I, 11 patients (6.5%) were mLenke type II, 34 patients (20.2%) were mLenke type III, 0 patients were mLenke type IV, 17 patients (10.1%) were mLenke type V, and 22 patients (13.1%) were mLenke type VI. They found that Utilizing the mLenke and simple morphologic classifications, it has been confirmed a relationship between curve morphology (main thoracic curve versus main lumbar curve) and brace success. It is potential that the main lumbar curves are less likely to progress than main thoracic curves are. Nevertheless, lumbar curves may respond more favourably to brace wear than main thoracic curves do. Moreover, 3.9% of thoracic curves were fused between 40° and 49°, and 2.6% of lumbar curves were fused between 40° and 49°.

Study 4: Angelo G. Aulisa et al evaluated the efficacy of Lyon bracing for the conservative treatment of adolescent females with idiopathic thoracic curves on the basis of the Scoliosis Research Society (SRS) Committee on Bracing and No Operative Management Standardization Criteria and followed the guidelines on management of idiopathic scoliosis with corrective braces, proposed by the International Society on Scoliosis Orthopedic and Rehabilitation Treatment (SOSORT). They found that the study showed that of the 69 patients with a definite outcome. Curve correction was done in 85.5 % of patients, curve stabilization was obtained in 13 % of patients and curve progression was in the only 1.5 %. None of the patients were recommended surgery post-bracing , about 17 patients who leave the treatment, at the time of abandonment (14.4 age) have achieved curve correction in 13 cases (77 %), stabilization in 53 cases (18 %) and



progression in 1 case (5 %). They also found that the study confirms the effect of lyon brace to stabilization and correction of thoracic curves in

AIS plus to that other results together with the recent reported literature in 16,17 and 21 adoption conservative approaches based on the SOSORT and SRS give better results than those with only SRS criteria.

Study 5: Gozde Gur et al evaluated the effects of a spinal brace on postural stability and Cobb angle were investigated in this study. Thirteen pediatric patients (10 females, three males) (12–17 years) with AIS were recruited to participate in the study. Cobb angle was assessed by X-ray analyses, and postural stability was tested by computerized dynamic posturography in braced and unbraced conditions. They found that Among the 38 AIS patients admitted to the department, 25 fulfilled the inclusion criteria the study subjects were 13 patients (10 females, three males) who complete the study there was Improvement in certain parameters of postural control were effected in subjects while wearing the brace, including proprioception, equilibrium, and rhythmic movement ability. Furthermore, reduced Cobb angles were observed in the spines of subjects wearing the brace.

Study 6: N. Cobetto et al assessed the effectiveness of Immediate in-brace correction designed using Computer-Aided Design and Manufacturing (CAD/CAM) and Finite Element Model (FEM) (NewBrace Design) vs. CAD/CAM only (CtrlBrace design) for the conservative treatment of Adolescent Idiopathic Scoliosis (AIS). In this randomized controlled and blinded study, 40 patients aged between 10 and 16 years diagnosed with AIS (Cobb angles between 20° and 45°) were recruited. They found that Using FEM simulation with CAM/CAD techniques was found to be more efficient in correcting thoracic curves when focusing on in-brace correction. The usage of this simulation platform allowed the orthotists to avoid any excessive pressure and to adjust the openings and relief zones on the brace. Furthermore, braces were lighter, thinner, and had a less body surface coverage which give them an additional advantage. These results suggest that long-term effect of bracing in AIS can be accordingly improved.

Study 7: David E. Lebel et al evaluated the differences in in-brace radiographic correction comparing a custom thoracic-lumbo-sacral-orthosis (TLSO) (T) brace to a Cheˆneau type TLSO (C) brace using 3D EOS reconstruction technology. Our primary research question was the 3D effect of brace on the spine and in particularly the apical vertebra rotation (AVR). was a retrospective comparative analysis of patients with adolescent idiopathic scoliosis who had orthogonal AP and lateral X-rays with and without brace. A3D image of the spine was reconstructed. Coronal, sagittal and axial spine parameters were measured before bracing and then on the first post-brace X-ray. Brace efficacy in controlling coronal, sagittal and axial parameters was evaluated. Eighteen patients treated with the C brace and ten
patients treated with the T brace were included. No difference was found regarding patients' age, gender, magnitude of Cobb angle, sagittal parameters or AVR at inclusion. Following bracing, AVR was significantly reduced by the C brace compared to the T brace [average correction of 8.2_ vs. 4.9_ (P = 0.02)]. Coronal and sagittal correction did not differ significantly between the two groups. They were able to demonstrate that braces differ
in their immediate effects on the spine. Although clinical relevance should be evaluated in a future trial we feel that the ability to measure treatment effects in 3D, and especially the transverse plane, is an important tool when evaluating different treatments.

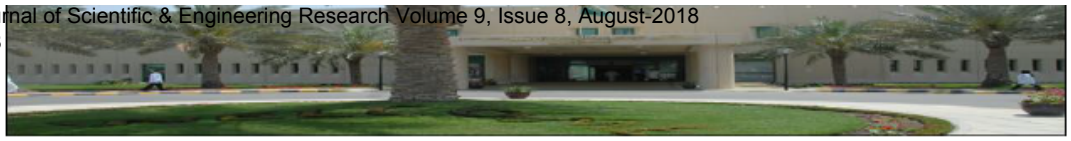
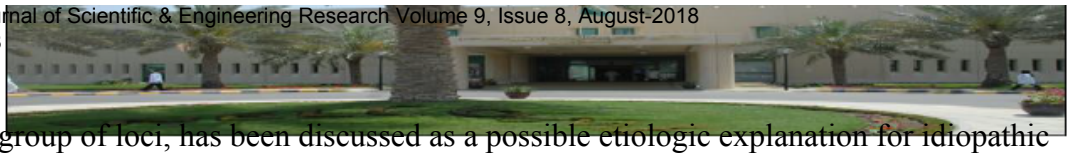


Table 1. The in-brace correction and success rate of different braces.

Brace Types		Author (yr)	N	Av Age	Cobb Angle (°)			% Corr (I)	% Corr (W)	% Imp	% Stable	% Worse	% S. T	% Surg
	Name				T0	T1	T2							
Symmetrical Braces	Boston	Emans *et al.* 1985	295	13.2	29	14.6	25.6	-50	-11.7	44	49	7		11
	DDB	Grivas *et al.* 2003	28	13.2					-4.6	35	46	18		4.3
	Boston	Lou 2006	20	13.4	32.2	22.7	35	-28	+8.7		75	25		
	TLSO	Janicki *et al.* 2007	48	12.7	33.6		46.8		+39.3	0	15	85	56	
	TLSO	Gammon *et al.* 2010	35	13	33		37.5		+13.6	60%≦5°; 80% did not progress to 45°		46.9	20	
	Lyon	de Mauroy *et al.* 2011	1338	13.8	29.5	10.8 (-18.7)	21.3 (-8.2)	-63.4	-27.7	67.2	27.8	5		
	OMC	Kuroki *et al.* 2015	31	12	27.3	14.5	28.6	-46.9	+4.8	19.4	48.3	32.3	9.7	
Asymmetrical Braces	**RSC**	Rigo *et al.* 2003	106	12	34								14.1	
	Chêneau	Landauer *et al.* 2003	34		30.4		25.2		-17.1	78		22		
	Rosenberger	Spoonamore *et al.* 2004	71		29.5	21.5	30.7	-27.1	+4.1				56	30
	Chêneau Light	Weiss *et al.* 2007	64	12.9	35.6	19.2		-53.9						
	LA brace	Kessler 2008	40		30	14.9		-51		80		20		
	Chêneau	Zaborowska Sapeta *et al.* 2011	79		32.9					25.3	22.8	51.9	12.7	
	PASB	Aulisa *et al.* 2012	110		29.3	13.9		-52.5						
	Chêneau	Weiss and Werkmann 2012	34	12.1	31	13		-59						0
	Chêneau Gensingen	Borysov and Borysov 2013	92	12.4	29.2	12.8		-56						
	Chêneau Gensingen	Weiss *et al.* 2013	21	12.2	31.3	10.7		-66						
	Chêneau	de Giorgi 2013	48	11.3	27	7.6	11	-72	-59.3					
	ART	de Mauroy *et al.* 2014	72		30	7.6		-76						
	RSC	Maruyama *et al.* 2015	33	11.9	30.8	14.2		-53.8		24.2	51.5	24.2	12.1	3
Flexible	Spinecor	Coilliard *et al.* 2007	170							59.4		40.6	1.2	22.9
	Spinecor	Gammon *et al.* 2010	32	13.2	31		37.7		+21.6	53.1% ≦5°; 72% did not progress to 45°		57.1	28	

Discussion:

Scoliosis is a common disease with an overall prevalence of 0.47–5.2 % in the current literature [7]. The female to male ratio ranges from 1.5:1 to 3:1 and increases substantially with increasing age. The prevalence of curves with higher Cobb angles is substantially higher in girls than in boys: The female to male ratio rises from 1.4:1 in curves from 10° to 20° up to 7.2:1 in curves >40° [11]. We have searched PubMed for any related topic discussing the effectiveness of spinal bracing on scoliotic patients. In this study we aim to update ourselves on the recent topics which deal with the effect of spinal bracing on scoliotic patients with different curved angles.
Recently studies showed bracing is an effective treatment to prevent curve progression. The precise cause of idiopathic scoliosis remains unknown, but many researches avenues exist. The causes of scoliosis vary; a primary muscle disorder has been contributed as a possible cause of idiopathic scoliosis [8, 12-17]. The contractile proteins of platelets resemble those of skeletal muscle, and calmodulin is an important mediator of calcium-induced contractility. An elastic fiber system defect (abnormal fibrillin metabolism) has been offered as one potential etiologic explanation for idiopathic [27] scoliosis. Such abnormal connective tissue has not been found universally in patients with idiopathic scoliosis [25]. Distorted skeletal growth, probably with its root cause at a



gene locus or group of loci, has been discussed as a possible etiologic explanation for idiopathic scoliosis [13]. The majority of patients with idiopathic scoliosis present because of a deformity.

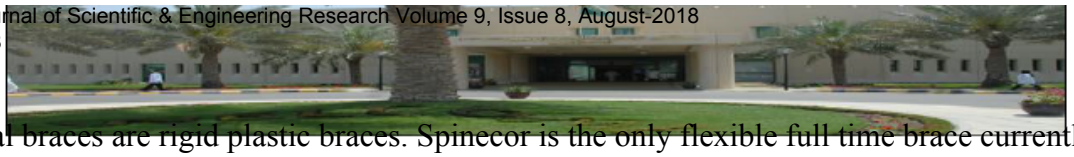
This may be patient or family perception of asymmetry about the shoulders, waist, or rib cage [13]. The Adams forward-bending test (in conjunction with the use of a scoliometer) has been

found to be an effective screening tool. Physical examination includes a baseline assessment of posture and body contour [13]. Shoulder and protruding scapulae are common [9]. In the most common curve pattern (right thoracic), the right shoulder is consistently rotated forward, and the medial border of the right scapula protrudes posteriorly [26]. Assessment of lower-extremity (and often upper-extremity) reflexes should be performed. Abdominal reflex patterns should also be assessed [26]. The presence or absence of hamstring tightness should be investigated, and screening should be performed for ataxia and/or poor balance or proprioception (ie, Romberg test) [28].

There are at present several types of braces on the market; there are symmetrical and asymmetrical braces, rigid and soft braces, full time braces and nighttime braces [27] These braces have different biomechanical corrective principles, with varying effectiveness in halting progression of curvatures [9]. Asymmetrical braces in general fared better than symmetrical braces and flexible braces in correction of curvatures, with the providing more than 60% of the correction [13]. The Lyon brace had the highest correction effect among the symmetrical braces. It corrected an average of 63.4% [10].

Types of outcomes measure primary outcomes. The primary outcome measures were pulmonary disorders, disability, back pain, QOL, and psychological and cosmetic issues. Secondary Outcomes. The secondary outcome measures were clinical and radiographic parameters. [10] Very short (any result before the end of bone growth), short (results at the end of bone growth), and long-term (results in adulthood) outcomes were considered. Progression of scoliosis was measured by: Cobb angle in degrees (absolute values) Number of patients who had progressed by _5° Cobb (minimal clinically important difference).

The final outcome of brace treatment depends on both in-brace correction and compliance and as the asymmetrical braces had a higher degree of correction when compared with symmetrical [22] braces, it is not surprising to find that the success rate of asymmetrical braces is higher than that of the symmetrical braces. The success rate of the Chêneau derivates has been described in a few outcome studies. The Rigo System Chêneau brace (RSC) had a success rate of 76% [10], which is not much different from the success rate of 72% achieved by the Boston brace in an RCT [7]. In a prospective controlled trial with a very homogenous sample of patients at high risk for progression, the success rate with the hand made Chêneau brace was at 80% [22]. In a retrospective series [28], the success rate of the Gensingen brace was more than 95%; none of the patients was operated on. A similar outcome was reported in a preliminary prospective cohort study using the Gensingen brace (more than 90%) [23]. Bowman (2011) was of the opinion that symmetrical braces do not provide sufficient correction to prevent curve progression [14]. To achieve high in-brace correction, the interior shape of the brace has to be asymmetrical in configuration [14]. The large correction in curvatures may partly compensate for low compliance in wearing of the brace [15]. Though asymmetric braces may be more effective than symmetrical braces in the treatment of AIS, not all asymmetric braces perform equally well in different types of scoliosis. As the thoracic spine is more rigid, the percentage of correction achieved through bracing is less than that of the thoracolumbar and lumbar spine [10, 13] (Table 2). Moderate curves correct less with bracing when compared with milder curves [8]. Also, the percentage of in-brace correction was less when the Cobb angle was at or above 30o, rather than at 20-29° [8]. The majority of the full time



scoliosis spinal braces are rigid plastic braces. Spinecor is the only flexible full time brace currently commonly in use. From the data, it is apparent that asymmetrical braces are more effective than symmetrical braces in the treatment of AIS, with ARTbrace and

Gensingen braces ranking high in correction. Also, rigid TLSO are more able to control progression of curvatures than the flexible Spinecor. Recently, a case report has been published showing that long-term corrections of about 20° are possible when starting treatment early, at an immature stage and with asymmetric braces of recent standards [19]. Regarding QOL, the rigid brace caused significantly more problems with heat (85% vs. 27%), as well as difficulties with donning and doffing, the patients using the elastic braces had difficulties with toileting. [25] There is low-quality evidence from 1 RCT (N _ 43) that a rigid brace is hotter and more difficult to put on and take off than an elastic one, but elastic one is difficult to maneuver during toileting.

Table 2. The in-brace correction of different braces in scoliosis of different regions.

Braces	Author (yr)	Thoracic			Thoracolumbar			Lumbar			Double Curve						Remarks
		ICA	BCA	% Corr	ICA	BCA	% Corr	ICA	BCA	% Corr	ICA		BCA		% Corr		
											Th	LB	Th	LB	Th	LB	
Boston	Emans 2003	24	12.7	- 47	24	6.5	-73	24	9.1	-62	24		10.8		-55		Prebrace Cobb angle 20 - 29°
Boston	Emans 2003	35	17.8	- 49	34	16	-53	31	15.2	-51	35		19.9		-43		Prebrace Cobb angle ≥30°
DDB	Grivas 2003	25	19	-24	24	21.6	-10				23.2	21.2	20.8	22.1	-10.3	+4.2	
Chêneau	Landauer 2003	30.7	12.5	- 59.3													Hi corr gp
Chêneau	Landauer 2003	32.2	23.1	- 28.3													Low corr gp
LA Brace	Kessler 2008	31	12.4	- 60	31	13.6	-56	40	14	-65					-30		
Lyon	De Mauroy 2011	32.3	15.1	-53.3	28.5	9.4	-67	28	7.2	-74.3	31.5	28.8	15.8	11.7	-49.8	- 59.4	
PASB	Aulisa 2012				29.3	13.9	-52.5	29.3	13.9	-52.5							
RSC	Maruyama 2015			-34.4			-73.8			-73.8					- 48.8		

Abbreviation: ICA: initial Cobb angle; BCA: braced Cobb angle; % corr: percentage of correction; LA brace: Los Angeles brace; PASB: progressive action short brace; RSC: Rigo System Chêneau scoliosis brace.

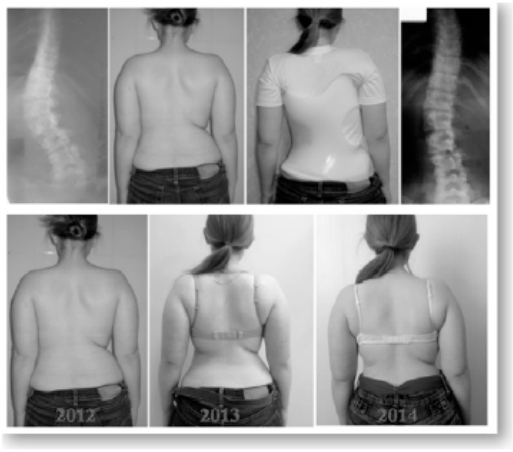
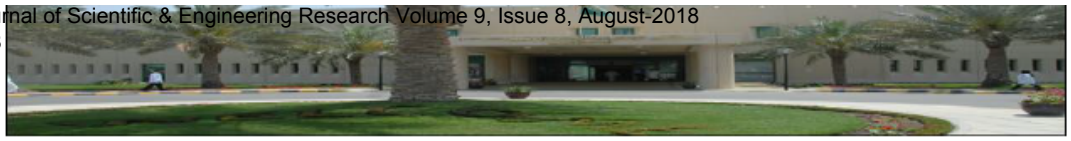


Fig. (3). Clinical and radiological improvement in a more mature girl treated with a Best Practice Chêneau style brace in the Ukraine.



Acknowledgment List:

Data collector:

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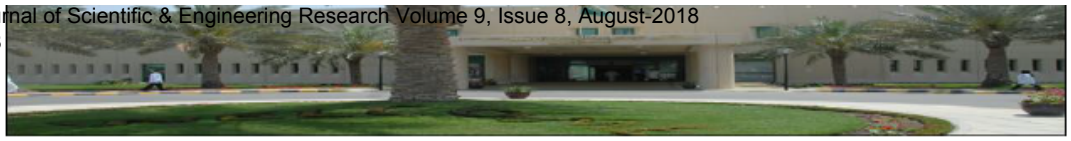

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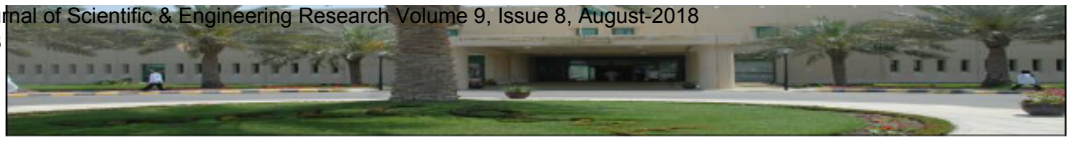

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