

# Clinical experience with orthotic repair of pectus carinatum

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**BACKGROUND:** Pectus carinatum is a congenital chest wall deformity characterized by protrusion of the sternum and adjacent costal cartilages. Multiple treatment options are available for correction of pectus carinatum.

**OBJECTIVE:** We report our initial experience with first-line treatment using a custom fitted dynamic compression orthosis.

**DESIGN:** Prospective evaluation of all patients seen between November 2013 and December 2014.

**SETTING:** University hospital.

**PATIENTS AND METHODS:** The treatment protocol for patients who had pressure for initial correction  $\leq 7.5$  psi included a custom-fitted and adjusted dynamic compression orthosis and frequent clinic visits. Patient satisfaction was assessed after 12 months.

**MAIN OUTCOME MEASURES:** Patient satisfaction score.

**RESULTS:** Eighteen patients (17 male and 1 female) (age: mean, 15.5 y; range, 10-23 y) completed treatment or continued in the study. Mean pressure for initial correction was 4.5 psi (range, 2.2-7.3 psi), bracing time was 12.8 hours/day (range, 8-24 h/d), and satisfaction score was 3 (scale: no correction, 0; complete correction, 4). There was complete correction in 7 patients (39%), remarkable improvement in 5 patients (28%), minimal improvement in 3 patients (17%), and no correction in 3 patients (17%). There were no major complications.

**CONCLUSION:** Treatment with dynamic compression orthosis for chondrogladiolar pectus carinatum provided favorable outcomes in compliant patients. We recommend this as first-line treatment for this condition.

**LIMITATIONS:** No objective findings. Satisfaction scores are subjective. We recommend chest CT for follow up and use of a radiological tool for comparison.

Pectus carinatum is a congenital chest wall deformity characterized by anterior protrusion of the sternum and adjacent costal cartilages. Pectus carinatum is observed more commonly in male than female patients (male:female ratio, 5:1). Pectus carinatum has no known cause, but may occur in association with congenital heart disease, Marfan syndrome, and other connective tissue disorders.<sup>1</sup> In chondrogladiolar pectus carinatum, which is the most common type of pectus carinatum, the middle and lower parts of the sternum protrude forward and the costal cartilages are concave and depressed.

Surgical repair has been the primary treatment during the past five decades. However, successful correction of pectus carinatum with a dynamic compression orthosis has been reported.<sup>2</sup> The principle of orthotic

repair of pectus carinatum is based on the Wolff law; healthy bone and cartilage that are loaded with a constant and increasing force will adapt, strengthen, and remodel. We present our experience with orthotic repair for patients who had chondrogladiolar pectus carinatum.

## PATIENTS AND METHODS

Between November 2013 and December 2014, all patients with chondrogladiolar pectus carinatum treated at King Abdulaziz University Hospital, Jeddah, Saudi Arabia, were included in this study and treated with a custom-fitted dynamic compression orthosis. At the first consultation, a complete history was taken, physical examination was performed, and pressure for initial correction was measured by applying an electronic measur-

ing device on the deformity until a normal shape was observed (**Figure 1**). Further anthropometric measurements were obtained to customize the dynamic compression orthosis (**Figure 1**).

The orthosis included three lightweight aluminum curved segments, assembled to create a belt surrounding the chest wall at the level of the pectus carinatum deformity. A cushioned compression plate was attached to the anterior segment of the orthosis and applied to the deformity (**Figure 2**). Patients were advised to wear the brace for 15 to 24 hours per day. After the initial orthotic fitting, patients were reevaluated in the clinic within 4 weeks to assess compliance and followed every 3 months until correction was completed. Patient compliance was rated as satisfactory when daily use of the brace was  $\geq 15$  hours and there were visits to the clinic every 3 months. Patient satisfaction with the result was measured subjectively by patients or parents using a qualitative scoring scale (**Table 1**).

## RESULTS

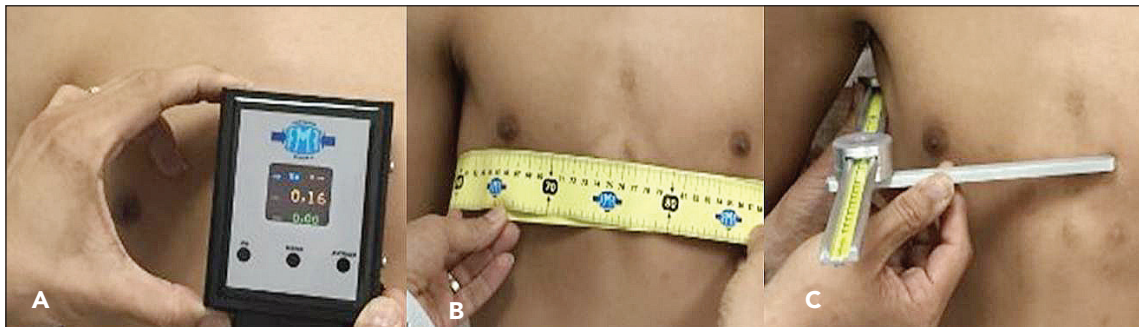
Eighteen patients were treated for chondrogladiolar pectus carinatum, including 17 male patients (94%) and 1 female patient (6%) (age: mean, 15.5 y; range, 10-23

y). The chondrogladiolar pectus carinatum included a central deformity in 9 patients (50%) and lateral deformity in 9 patients (50%). Mean bracing time per day was 12.8 hours (range, 10-24 h), and the mean pressure for initial correction was 4.5 psi (range, 2.2-7.3 psi).

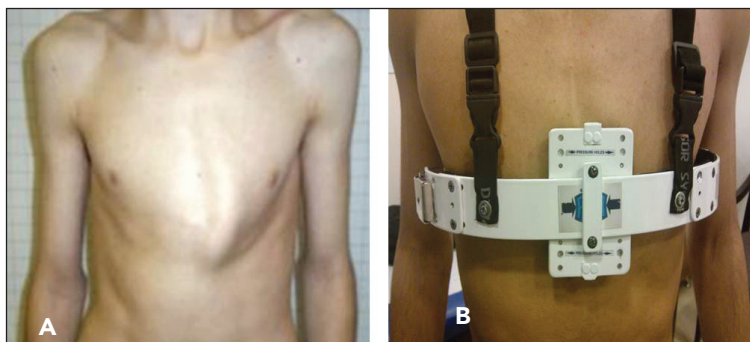
Follow-up was 12 months. Seven patients (39%) with a mean pressure for initial correction of 3.5 psi and bracing time  $\geq 15$  hours/day had complete correction of the deformity (**Table 1**). In 5 patients (28%) who had a mean pressure for initial correction 5.6 psi and bracing time 8 to 15 hours/day, good improvement was achieved. In 6 patients (33%) who had a mean pressure for initial correction of 4.9 psi and bracing time  $< 8$  hours/day, there was minimal improvement or no correction (**Table 1**). There were no complications during the study, and no patient had recurrence of deformity after removal of the dynamic compression orthosis. A significant improvement in pectus carinatum patient before and after dynamic compression orthosis is shown in **Figure 3A, B**.

## DISCUSSION

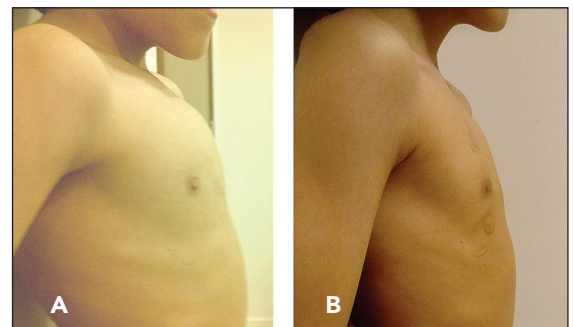
Pectus carinatum describes a range of chest wall deformities characterized by a convex protrusion of the sternum and the adjacent costal cartilages. The condition is



**Figure 1.** Patient with chondrogladiolar PC demonstrating measurement of PIC in psi (A), Chest circumference in cm (B) and thoracic depth in cm (C).



**Figure 2.** Patient with chondrogladiolar PC (A) and with fitted dynamic compressor brace (B).



**Figure 3.** A Picture of a patient with chondrogladiolar pectus carinatum before treatment (A), a picture of the same patient after treatment (B).

**Table 1.** Subjective patient satisfaction scale for pectus carinatum and results of treatment with dynamic compression orthosis.\*

Grade	Definition	No. of patients (%)
0	No correction	3 (17)
1	Minimal improvement	3 (17)
2	Good improvement	0 (0)
3	Remarkable improvement	5 (28)
4	Complete correction	7 (39)

\*n=18 patients. Data reported as number (%).

thought to result from the abnormal growth of the costal cartilages resulting in an anterior chest wall protrusion of varying severity. The type of pectus carinatum type is determined by the appearance of the anterior chest wall and the location of prominent and depressed areas. The deformity may be classified as both chondrogladiolar and chondromanubrial.

The present results showed that dynamic compression orthosis was successful for treatment of chondrogladiolar pectus carinatum in patients who had better compliance and lower pressure for initial correction.

Although surgery has been the primary treatment for pectus carinatum, surgery requires general anesthesia and may cause postoperative pain and a residual visible scar. Several reports have shown that compression bracing to correct pectus carinatum is safe, reliable, and effective.<sup>2-5</sup> Patient compliance is the most important factor that contributes to good results with the dynamic compression orthosis. The therapy is effective when the orthosis is worn  $\geq 15$  hours per day, as confirmed in our study.

Orthotic repair in childhood and early adolescence seems to be the optimal time for initiating this approach as the deformity is flexible and reducible. Patients are

typically instructed to wear the brace for 15-24 hours a day until complete correction is achieved. The orthosis should not be worn during bath or physical exercise. After complete subjective improvement is noted, the maintenance phase is initiated with nightly brace wearing until linear growth ceases and by the age of 18 years.

Dynamic compression orthosis has advantages over other orthotic braces. The measurement of chest wall compliance with an electronic measuring device may serve as a predictor of treatment efficacy, facilitate patient selection for bracing, and predict duration of treatment. In addition, adjustment of pressure during treatment may help avoid skin necrosis and patient noncompliance. In patients who have pressure for initial correction  $\leq 7.5$  psi, the dynamic compression system may be the treatment of choice.<sup>6,7</sup> Our experience in patients with pectus carinatum treated with the external dynamic compression system was very good. We limited pressure for initial correction  $\leq 7.5$  psi for all patients. We observed good results in younger patients within 2 to 3 months when they wore the dynamic compression orthosis for 24 hours/day. Our success is evidence of the importance of patient compliance and motivation and parental support. Patient compliance with regular wearing of the orthosis for long hours per day is important for success with this treatment method.<sup>8,9</sup>

A limitation of our study is that we used only satisfaction scores, which are subjective. No objective findings were assessed. We recommend chest computed tomography for follow up and a radiological tool for comparison.

In conclusion, the present results show that the dynamic compression orthosis is effective nonoperative therapy in patients who have pectus carinatum. We currently are offering this method as first-line treatment for patients who have chondrogladiolar pectus carinatum.

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