

# Bone Mineral Density as a Marker for the Timing of Pectus Bar Removal After Nuss Procedure

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Bone mineral density (BMD) was measured to establish the optimal timing for pectus bar (PB) removal after the Nuss procedure (NP). Twenty-three patients who had PB removal after NP were assessed according to: age at PB insertion/removal, duration of insertion, clinical outcome and BMD. BMD was measured just prior to insertion (in-BMD) and just prior to removal (out-BMD) and %BMD was determined by dividing subject BMD by BMD for age-matched controls. Age at insertion ranged from 4.3–2.7 years and age at removal ranged from 6.3–14.1 years. Duration of insertion ranged from 1.4–3.9 years. There were two cases of recurrence after NP. In these cases, PB insertion occurred at 5 and 4 years, and removal was at 6 and 8 years respectively and both BMD and %BMD were below normal. In the nine cases with no recurrence, PB removal occurred between 6–8 years old; BMD was normal, and %BMD was higher than in the two cases with recurrence. BMD and %BMD would appear to be valuable markers for the timing of PB removal. [*Asian J Surg* 2009;32(2):114–7]

**Key Words:** bone mineral density, Nuss procedure, pectus bar, pectus excavatum

## Introduction

Pectus excavatum (PE) is the most commonly encountered chest wall deformity. Patients present most commonly with a combination of aesthetic concerns and restricted pulmonary function causing exercise-induced dyspnea.<sup>1</sup> For the past half century, PE was corrected by subperichondrial removal of the offending costal cartilage, mobilisation of the sternum, and stabilisation; the technique was first described by Ravitch in 1949.<sup>2,3</sup> In the late 1980s, Nuss began to use a minimally invasive approach by temporarily placing a convex metal bar substernally through small, bilateral incisions. It is associated with less morbidity than the traditional Ravitch repair, and because it is effective in the long term, it has become the standard technique for the surgical treatment of PE.<sup>4–11</sup>

Many authors advise that the pectus bar (PB) should be removed 2 to 3 years after insertion, although there is no objective basis for this, and we also used this principle to avoid affecting normal rib growth. However, recurrence can occur, and there are no guidelines for PB insertion and removal available.<sup>7,12</sup>

Based on this, we considered the use of bone mineral density (BMD) as a marker for determining when the PB should be inserted and removed. Although BMD is influenced by racial background, quality of bone growth, and the effects of aging and metabolic disorders, it is easily measured using the second to fourth lumbar vertebrae, and BMD measured at L2–L4 is regarded to reflect bone status throughout the body.<sup>13–16</sup> We hypothesised that BMD might be a reliable marker for PB insertion/removal in patients with NP.

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The aim of this study was to establish the optimal timing for PB removal after NP by measuring BMD.

**Materials and methods**

Twenty-three patients (17 male, six female) who had PB removal after NP between 2000 and 2007 were enrolled in this study. Age at PB insertion/removal, duration of insertion, clinical outcome, and BMD were assessed.

The clinical outcome was determined subjectively by a single surgeon; excellent = no depression, good = mild depression, fair = moderate depression, and poor = recurrence requiring repeat surgery.

BMD was measured using dual-energy X-ray absorptiometry (QDR-2000 Hologic Inc, Bedford, MA, USA) according to a technique that described elsewhere.<sup>15</sup> In this study, we measured BMD supine using L2 through L4. In all 23 patients, BMD was examined just prior to insertion of the PB (in-BMD) and just prior to removal of the PB (out-BMD). The %BMD was measured by dividing subject BMD by standard mean BMD for age and sex matching healthy Japanese children (Figure 1).<sup>17</sup> In other words, normal %BMD is 1.0 (Figure 2).

Data were expressed as mean ± standard deviation and were analysed using the Mann-Whitney U test for non-parametric variables. A *p* value of <0.05 was considered to be statistically significant.

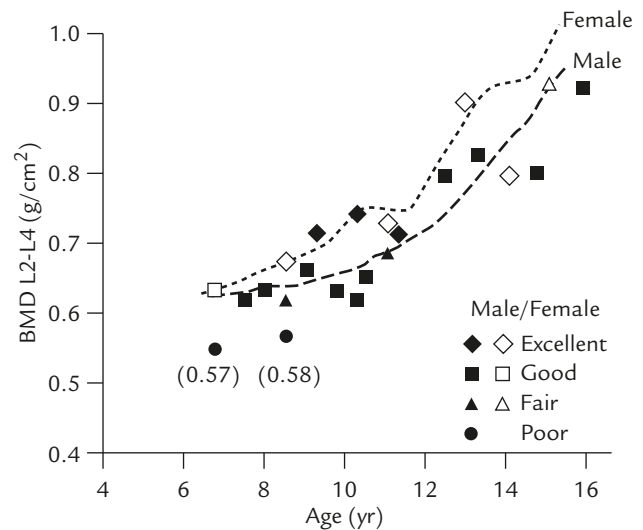
**Results**

Age at insertion ranged from 4.3–12.7 years and age at removal ranged from 6.3–14.1 years. Duration of insertion ranged from 1.4–3.9 years. Clinical outcome was described as excellent in seven, good in 11, fair in three, and poor (recurrence) in two. Mean ages at insertion/removal according to outcome are shown in Table. An interesting point is that mean age of insertion/removal in the poor (recurrence) group was younger than for the other three groups (excellent, good, and fair). In the two cases with recurrence, PB was inserted at the ages of 5 and 4 years and removed at 6 and 8 years respectively. In these two cases NP was performed earlier than usual because of clinical indications (obvious chest pain and respiratory distress).

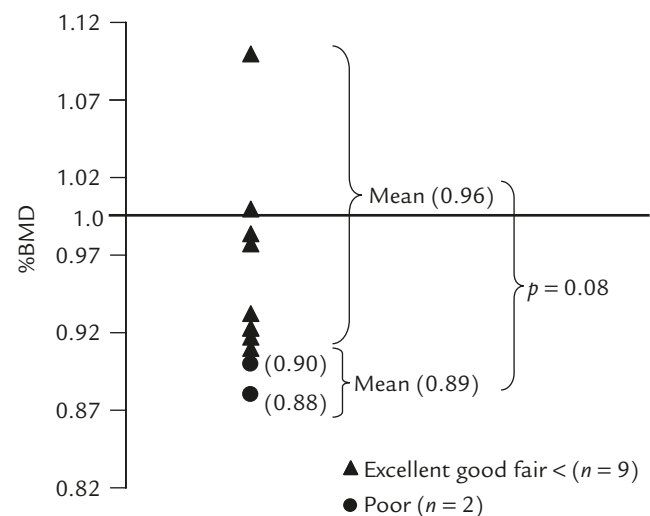
The dotted lines in Figure 1 show standard mean BMD for age and sex matched healthy Japanese children. As shown in Figure 1, the majority of the 21 subjects in

the excellent, good, and fair outcome groups had BMD at the time of PB removal close to standard mean values. However, BMD in the two subjects in the poor (recurrence) outcome group was much lower than standard, and even lower than in the subjects in the other three groups; i.e., BMD at PB removal was 0.57 and 0.58 g/cm<sup>2</sup> respectively.

Figure 2 shows %BMD at the time of PB removal according to subject group. Again, both BMD and %BMD were below normal in the two subjects in the poor (recurrence) outcome group. In the nine cases with no recurrence, PB removal was between 6–8 years old and BMD was normal and %BMD was higher than in the two cases with



**Figure 1.** Standard mean BMD for age and sex matched healthy Japanese children. BMD of patients in the excellent, good, and fair outcome groups were close to standard BMD.



**Figure 2.** %BMD in 11 patients who had PB removal between 6–8 years of age.

**Table.** Mean age at PB insertion/removal according to outcome

Clinical outcome	Mean age (yr)	
	PB insertion	PB removal
Excellent (n=7)	8.4±2.5	10.7±2.1
Good (n=11)	7.5±2.7	9.5±2.7
Fair (n=3)	10.1±2.2	12.6±3.2
Poor (n=2)	5.1±0.6	7.7±0.5

recurrence (0.88 and 0.90). However, this difference was not statistically significant ( $p=0.08$ ).

Both poor outcome cases had to redo NP (PB reinsertion) at the ages of 9 and 8 years respectively, and in both, the PB was removed 2 year later. Outcome was excellent in both cases, and interestingly, BMD at PB removal after redoing NP were normal (0.72 and 0.70, respectively), meaning their %BMD were closer to 1.0 (0.95 and 0.97) than previously (0.88 and 0.90).

## Discussion

In general, the severity of deformity in PE is evaluated objectively using the Haller index (ratio of transverse to antero-posterior diameters of the chest) obtained using chest CT.<sup>18</sup> At our institution, surgical repair is indicated if the Haller index is over 3.2, and the patient is clinically symptomatic, with chest pain and/or respiratory distress and manifestations of psychological distress based on aesthetic issues.

Although NP has gained wide acceptance for the minimally invasive repair of PE, it is associated with a recurrence rate of some 4.3%<sup>5</sup> and this has been generally attributed to the timing of PB insertion/removal.<sup>7</sup> We found that the majority of subjects with good outcome had normal BMD at the time of PB removal; whereas in the poor (recurrence) outcome group, BMD was markedly below normal. Thus, bone status appears to be related to clinical outcome in NP patients.

According to the standard mean BMD curve for age and sex matched healthy Japanese children, normal BMD begins to increase markedly around 8–9 years old and plateaus around 14–15 years old.<sup>17</sup> Thus, we postulated that the optimum age for insertion would be around 8–9 years old, the optimum age for PB removal would be around 13–14 years old, and that after the age of 15 years, ossification would appear to be too well established for

NP to be clinically effective. This seems to be reflected in the literature by a recent trend for the reported age at PB insertion to be increasing (i.e., around 8 years old) compared with previous reports (5–6 years old)<sup>5,7</sup> but this seems to have occurred more as a result of clinical experience, rather than for any objective reason.

Our results would indicate that BMD and %BMD could in fact be used as objective markers for planning the timing of PB insertion/removal and although our subject numbers are limited, assessment of BMD and %BMD could provide valuable information for determining the timing of PB insertion/removal.

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