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Evaluation of risk factors associated with fragility fractures and recommendations to optimise bone health in children with long-term neurological condition

Xue Yi Jessica Leow[1], MBBS, Jonathan Tian Ci Tan[1], MBBS, Tong Hong Yeo[2], MBChB, FRCPCH, Kenneth Pak Leung Wong[3], MB BCh BAO, FRCS, Arjandas Mahadev[3], FRCSEd, Bixia Ang[4], BSc(Hons), Rashida Farhad Vasanwala[5], MBBS, FRCPCH, Zhi Min Ng[2], MMed, MRCPCH

[1]Yong Loo Lin School of Medicine, National University of Singapore, [2]Department of Paediatrics, [3]Department of Paediatric Orthopaedics, [4]Department of Nutrition and Dietetics, [5]Department of Paediatrics, Endocrine and Diabetes Service, KK Women's and Children's Hospital, Singapore

Correspondence: Dr Ng Zhi Min, Consultant, Department of Paediatrics, KK Women's and Children's Hospital, 100 Bukit Timah Road, Singapore 229899. ng.zhi.min@singhealth.com.sg

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ABSTRACT

Introduction: The growing years are paramount for bone growth and mineral accrual. Children with long-term neurological condition (LTNC) have multiple risk factors for poor bone health and fragility fractures. In Singapore, this has not been studied systematically therefore we aim to evaluate the risk factors associated with fragilty fractures in children with LTNC.

Methods: In this study, the search for fragility fractures was done by a retrospective review of patients with LTNC who are under follow-up in the Paediatric Neurology clinic and of patients who presented with fracture to the Paediatric Orthopaedic clinic. Information on patient's demographics, medical history, intervention, biochemical bone markers and fracture history were collected.

Results: In a tertiary clinic population of 136 patients with LTNC, 65% were dependent on mobility (GMFCS V), 60% were underweight and 60% were fed via gastrostomy or nasogastric tube, or on oral pureed diet. Furthermore, 60% were on anticonvulsants. The fracture rate was 3% in this population and was associated with low-impact activities such as transfer and dressing. Only 7.4% had a vitamin D level measured and 33% had calcium measured.

Conclusion: The local prevalence of fragility fractures in children with LTNC who are under follow-up at the Neurology clinic was found to be 3%. Risk factors identified were limited ambulation and compromised nutritional status associated with feeding difficulty. Recommendations to optimize bone health in children with LTNC were made. These include promoting weight-bearing activities, looking out for underweight, avoiding vitamin D deficiency and ensuring adequate calcium intake.

Keywords: bone health, fragility fracture, long-term neurological condition, neurodisability

INTRODUCTION

Long term neurological condition (LTNC) refers to a diverse set of conditions resulting from disease or injury of the nervous system, which affects an individual for life. Examples of such conditions include cerebral palsy, acquired brain or spinal cord injuries, neurogenetic or neurometabolic disorders, neuromuscular diseases and many others. Children with LTNC have limited mobility and physical activities throughout their critical periods of bone growth and mineral accrual. Also, children with LTNC face feeding challenges which compromise their nutrition[1,2] and contribute to poor bone health and osteoporosis, thus increasing their risk of fragility fractures.[1] Fractures lead to pain, increased immobility and prolonged hospitalisation.

Previous studies have evaluated possible factors that affect bone health in children with specific neurological conditions. A systematic review of patients with spina bifida had shown that a higher level of neurological impairment, non-ambulatory status, physical inactivity and contractures were risk factors for higher fracture rates.[2] A study involving children with cerebral palsy reported fracture incidence of 2.7-4.5% and associated risk factors were limited ambulation, feeding difficulties, anticonvulsant use and lower body fat mass.[3]

However, there is lack of data on bone health and fragility fracture in Asian children with LTNC. Thus, we aim to evaluate clinical and biochemical risk factors associated with fragility fractures.

METHODS

This study was undertaken at KK Women's and Children's Hospital in Singapore, which is a tertiary paediatric centre. We reviewed data of paediatric patients aged 0-18 years who attended Neurology clinics between April and June 2018 and those who directly presented to Orthopaedic

clinic with fracture from 2009-2018. Inclusion criteria were long term neurological condition with a Gross Motor Function Classification system (GMFCS) of III and above. This means that these children required assistive devices such as walking aid and/or wheelchair for mobility. A higher GMFCS level corresponds to a higher requirement for assistance in mobility.[4] Children with osteogenesis imperfecta, pathological fractures from malignancy and those that sustained fractures from non-accidental injuries were excluded. Medical information from both electronic and case files was extracted and reviewed. Information on patient's demographics, medical history, exposure to sunlight, weight-bearing exercise, nutritional supplementation and weight were collected. Biochemical bone markers (serum alkaline phosphatase (ALP), phosphate, calcium and vitamin D) and fracture history were recorded. History included the age of occurrence of fracture, location and mechanism of injury. The institutional review board granted waiver for this study. Patients or the public were not involved in the design, conduct, reporting or dissemination plans of our research.

RESULTS

A total of 1,666 patients from the Paediatric Neurology clinic were reviewed, of which 136 patients had LTNC, and four of these patients (3%) sustained fragility fractures. Age of patients ranged from 2 to 18 years, with a mean age of 11.4 years. Patient characteristics are summarised in Table 1. Majority of our patients (60.3%) had a background of cerebral palsy. Other LTNC comprised of mostly chromosomal anomaly and myopathies. The dominant motor feature was spasticity. Majority of the patients were GMFCS level V (64.7%). In terms of risk factors affecting bone health, 80 out of 136 (58.8%) children with LTNC were on at least one anticonvulstant and seven (5.1%) children were on steroids. In terms of nutritional status, 131 (96.3%) children had

recent weight taken but only 92 (67.6%) had recent height taken and BMI recorded. 81 (60.0%) children were underweight with mean weight standard deviation score (SDS) -3.11 while mean height SDS was -2.73. 65 (47.8%) children were referred to and on follow-up with the dietitian. 81 (59.5%) children had feeding difficulties and had feeding adjuncts such as percutaneous endoscopic gastrostomy, nasogastric tube or oral pureed diet. Almost half of the children [65/136 (47.8%)] had serum albumin measured with mean level at 36g/L. Majority of patients [116/136 (85.3%)] had regular physiotherapy sessions but only 35 (25.7%) children had regular weight-bearing exercises. In terms of biochemical bone markers, 91 (66.9%) children and 126 (92.6%) children did not have calcium or vitamin D levels measured. Only a minority of patients, ten (7.4%) children and 32 (23.5%) children were on calcium and vitamin D supplementation respectively. Of these 136 patients with LTNC, four children (2.9%) were found to have sustained fragility fractures before.

In addition to the four patients from neurology clinic, there were 11 children with LTNC identified from the Orthopaedic clinic who sustained fragility fractures. Fracture characteristics of total of these 15 patients are summarised in Table 2. Median age at which fracture occurred was 7.0 years (IQR: 5.0 – 12.0). The most common fracture location was the femur [11/15 (73.3%)], followed by the humerus [3/15 (20.0%)]. Majority of the fractures occurred during low impact activity, such as during transfer or dressing. Patient characteristics of these children with LTNC who had sustained fragility fractures are summarised in Table 3. All children were GMFCS level V, with dyskinesia present in two third of them (10/15, 66.7%). Six (40.0%) and three (13.3%) patients were on anticonvulsant and long term steroid respectively. Fourteen (93.3%) patients had regular physiotherapy sessions, but only one (7.7%) of them had regular weight-bearing exercises. In terms of nutritional status, twelve (80.0%) patients were underweight for their age with mean

weight SDS -2.91 and seven (46.7%) had suboptimal albumin levels. All patients had feeding difficulty and required gastrostomy/ nasogastric tube feeding or were on an oral modified diet. Eight (53.3%) patients were monitored for calcium levels, and they had adequate serum calcium. However, only two (13.3%) patients were monitored for their Vitamin D levels before the fracture. Out of eight (53.3%) patients who had Vitamin D levels taken before and at time of fracture, four were in insufficiency /deficiency range (9.3-18.1ng/ml), and four were in normal range (24.7-29.2ng/ml). One child was on daily 1000units of Vitamin D supplement, but the vitamin D level was in insufficient range when the fracture occurred. The other 14 children were not on any regular Vitamin D supplementation. Twelve children were started on regular Vitamin D supplements after sustaining the fracture. None of the patients had DEXA scan done before. Two patients had recurrent fractures. One patient had DEXA scan done after recurrent fractures and had severe osteoporosis with Z-score -5.3SD for the hip and -3.5SD for the lumbar spine. He was started on regular bisphosphonate infusion with intravenous pamidronate three monthly for one year. Repeat DEXA scan after one year showed interval improvement of BMD, 40.7% for the hip and 14.5% for the lumbar spine. There was no recurrence in fracture since the last fracture two years ago.

DISCUSSION

In this study, the prevalence of fragility fractures in children with LTNC who are on follow-up in Neurology clinic was estimated to be 3%. This finding is close to the rate of 4% found through a systematic review of five studies on children with cerebral palsy,[3] and 3.6% in schools for physically disabled children including cerebral palsy, traumatic brain injury, encephalitis, myopathy and chromosomal anomalies in Japan.[5] In our study, the risk factors for poor bone health include high GMFCS level, lack of regular weight-bearing exercises, being underweight,

feeding difficulty and use of anticonvulsant and steroid. The study also showed that only a minority of children had regular calcium and vitamin D monitoring and supplementation.

Risk factors for poor bone health

1) Limited Mobility

In our cohort of the children with LTNC and fractures, all were GMFCS V, indicating a lack of mobility and majority (93.3%) had no regular weight-bearing exercises. According to a study comparing DEXA scan of 85 non-ambulatory children with the incidence of fragility fractures, it was found that a low BMD was associated with a higher risk of fragility fracture.[6] A similar study performed in 619 children with muscular dystrophy or moderate to severe cerebral palsy also yielded the same association.[7] This suggests that lower BMD in non-ambulatory children has a higher risk of fragility fracture. In our study, the femur was the most common site of the fracture, which is in keeping with previous studies which suggested a strong correlation with the BMD Z-score of the femur and fracture.[8] This is likely as femur BMD is increased by greater mobility and weight-bearing, which is compromised in these children.[8]

Interestingly, four patients in our cohort had a fracture in non-weight-bearing bones such as the humerus and the clavicle. In these patients, three (75%) had dyskinesia as their presenting motor feature, suggesting that movement disorder can also predispose to fragility fractures, even in non-weight bearing bones. Dyskinesia has not been reported as a possible risk factor of fragility fractures in the current literature.

2) Undernutrition & Low weight

In this study, the majority of patients who sustained fragility fractures had poor nutritional status, as the majority were underweight and about half had low serum albumin levels. In a study by Henderson,[9] 107 children with cerebral palsy were assessed for factors that helped identify subjects with low BMD. The study found that in children with good nutritional status as indicated by normal weight for age, were more likely to have normal BMD as opposed to those with weight SDS less than -2 and feeding difficulty, who tend to have BMD Z-scores less than -2. Weight SDS for age could potentially serve as the best surrogate for BMD Z-score based on the regression equation quoted in the study by Henderson.[9] Another cross-sectional study by Afshinnia,[10] studied serum albumin levels with bone mineral density in an outpatient setting and found that osteoporosis was associated with lower levels of serum albumin and longer periods of hypoalbuminemia. This suggest that markers of nutritional status such as body weight SDS for age and serum albumin levels correlated with bone health, and by addressing this may improve bone health in these children.

3) Use of anti-convulsant and steroid

Many studies have suggested that anti-convulsant such as Phenytoin, Phenobarbitone and Carbamazepine increased the risk of fragility fractures due to induction of the cytochrome P450 enzyme.[11,12] In our cohort of 136 children with LTNCs, 58.8% were on anti-convulsant while 40.0% of children with LTNC who had sustained fragility fractures were on regular anti-convulsant. Corticosteroids are also known to decrease bone mass and increase vertebral fracture risk.[13] These are used in some patients with LTNC, mainly those with muscular dystrophies. In

our cohort of 136 children with LTNCs, only 5.1% were on steroids. However, of the total 15 children with fragility fractures, 13.3% of children were on steroids.

4) Calcium and Vitamin D

Most of the patients with LTNC in our study did not have a regular measurement of calcium and vitamin D levels: 66.9% and 92.6% of the patients did not have their calcium and vitamin D levels monitored respectively. This is likely because it is not a routine investigation and there is no guideline on when such investigations should be performed. Previous studies have shown that low body stores of vitamin D are prevalent in non-ambulant children with cerebral palsy.[14] Low body stores of vitamin D are reflected by low serum 25-hydroxyvitamin D levels. In small studies done on non-ambulant children, low vitamin D status was associated with the use of anticonvulsants and incidence of fractures; and vitamin D administration resulted in a decrease in alkaline phosphatase activity and increase in serum calcium and phosphate level.[15,16] In the systematic review by Fehling's, which states that while vitamin D and calcium were possibly effective in improving BMD, the data was inadequate to recommend on their effectiveness to prevent fragility fractures. However, given their possible efficacy and good safety record, the authors recommended Vitamin D and calcium supplementation, together with monitoring of their levels at baseline and adjusting the dosages till normal levels are reached.[17]

Utility of DEXA scan

Osteoporosis in children is defined as having a clinically significant fracture history and a low BMD Z-score.[18] All the patients in this study did not have bone health quantification with DEXA scan on their regular follow-up visits. After optimizing the risk factors associated with fragility

fractures in children with LTNC, there may be a role for regular assessment of BMD by DEXA scan in these patients. The challenge faced in real life is postioning of these children with contractures, spasticity and scoliosis in an optimal position to get desired area for beam projection and quantification of bone mass. There is current evidence supporting use of lateral femoral BMD instead of lumbar, hip and whole body DEXA to quantify bone mass.[19] If these high risk children with LTNC are found to have low BMD Z-scores, there may be a role for bisphosphonates to prevent fractures. Bisphosphonates are a group of drugs that inhibit osteoclastic bone resorption resulting in an increase in bone mass and improvement in bone strength. Some cross-sectional studies[20-22] have shown an improvement in vertebral and femoral BMD in non-ambulant children with cerebral palsy who were treated with 1 year of cyclical intravenous Pamidronate. However, in another study by Bachrach, pamidronate failed to provide lasting improvement in BMD.[23] Optimal duration of therapy is also not known. In addition, if used in excess, bisphosphonate can induce over suppression of bone turnover and can cause acute post infusion hypocalcemia and hypophosphatemia.[2] Thus, caution should be taken when deciding to initiate bisphosphonate treatment. Further study is needed to define indications for treatment, dosing and duration of bisphosphonate therapy in children with LTNC at risk for fragility fractures.

RECOMMENDATIONS

Given the prevalent problem of poor bone health in children with LTNC as shown in our study and lack of consensus guidelines on bone health monitoring in this group of patients in current literature, our institution has come out with the following recommendations to optimize bone health in children with LTNC. Refer Figure 1.

1. Promote weight-bearing activities

   There is consensus regarding effectiveness of weight bearing exercise in improving bone mineral density and decreasing fracture risk. In two non-blinded randomized controlled trials with weight bearing physical activity intervention, there was an increase in BMD in the intervention group, as compared with the control groups.[24,25] In another study, there was an almost fourfold reduced risk of fragility fractures in those children with GMFCS IV-V cerebral palsy who had used standing devices on a regular basis.[26]

2. Avoid Vitamin D deficiency

   Vitamin D is produced in the skin through exposure to sunlight. Thus, encouraging exposure to sunlight will be helpful. Individuals with darker skin colour require longer exposure (up to five to tenfold) to sunlight to make the necessary vitamin D.[27] However, topical use of sunscreen dramatically reduces the amount of vitamin D absorbed. A sun protection factor of 8 (SPF 8) reduces absorption by greater than 97%. Chronic sunscreen use can result in vitamin D deficiency. Minimum of 10 to 15 minutes of exposure 3 times a week before applying sunscreen is recommended.[27] Vitamin D is also found naturally in small amounts in some oily fish such as salmon, mackerel and fish liver oil. Supplementation with higher doses of Vitamin D should be considered in patients with chronic fat malabsorption or those taking anti-seizure medication. AAP guidelines[28] recommend aiming for a serum concentration of 25-OH-D at sufficiency range greater than 50 nmol/L. We suggest to check 25-OH-D level for children with LTNC at baseline and annually or opportunistically during blood taking.

3. Ensure adequate calcium intake

The systematic review by Fehlings et al concluded that calcium was possibly effective in improving BMD but there was inadequate data to support its effectiveness in preventing fragility fractures.[17] It recommended nutrient intake for calcium, appropriate for age and gender. This is especially true for patients with LTNC as they are at higher risk of calcium and vitamin D deficiency in view of compromised nutritional intake, regular ingestion of anti-epileptic drug and lack of exposure to sunlight.[23] On the other hand, excessive dietary calcium intake should be avoided as it might lead to risk of exacerbating constipation and increase risk of urolithiasis in non-ambulant children with LTNC.[2] Therefore, we suggest consideration of calcium replacement only if there is poor dietary intake of calcium.

We also recommend bone health monitoring and management for children who are assumed to have osteoporosis if they have any history of fragility fracture or bone pain.[29] Refer Figure 2.

CONCLUSION

In conclusion, this study evaluated the risk factors in children with LTNC for fragilty fractures. The risk factors affecting bone health such as limited ambulation, feeding difficulties and poor nutritional status are similar to other studies.We proposed guidelines for monitoring and optimizing bone health in children with LTNC. In addition to preventive measures & mitigating risk factors, the role of DEXA scan for assessment of bone mass in high risk patients and treament with bisphosphonates is the way forward to optimize bone health in children with LTNC. This also has impact in improving their quality of life. A prospective evaluation after implementing these guidelines is the current focus in the care of these patients at our institution.

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Figure 1: Recommendations to promote bone health in a child with LTNC

<table>
<tr><th colspan="3">Child with LTNC is at risk of osteoporosis if one or more Risk Factor(s) is fulfilled:</th></tr>
<tr><td colspan="3">• GMFCS IV, V (limited mobility, requires wheelchair for transport)
• Post-surgery immobilization (Spine/ Hip spica)
• Pre-existent contracture, stiff or dislocated joint(s)
• Feeding difficulties – inadequate oral intake/ on nasogastric tube or gastrostomy feeding
• On anti-convulsant
• On corticosteroid</td></tr>
<tr><th>DOCTOR'S REVIEW</th><th>DIETITIAN'S REVIEW</th><th>PHYSIOTHERAPIST'S REVIEW</th></tr>
<tr>
<td>- Regular clinical review
- Height/ Weight for age and gender
- Medication review
- Avoid vitamin D deficiency/ Encourage sun exposure (minimum 10-15min three times a week before applying sunscreen)
- Suggest to check 25-OH-D level at baseline and annually/ opportunistically during blood taking:
- Deficient <12ng/ml (or 30nmol/L)
Insufficient 12-20ng/ml (or 30-50nmol/L)
Sufficient >20ng/ml (or 50nmol/L)
- Prescribe Vitamin D according to 25-OH-D level.
- 400IU daily if level is normal
- 1000IU daily if insufficiency*; 2000IU daily if deficiency*
- *Dose for 3 months then followed by maintenance dose if repeat level is normal.(30)
- Referral to Dietitian and Physiotherapist
- Consider referral to Endocrine for consideration of early DEXA scan in extremely high risk patients.</td>
<td>- Height/ Weight for age and gender
- Review dietary intake
- Ensure adequate calories and protein intake
- Ensure adequate Calcium intake:
1-3yo=500mg elem Ca
4-6yo=600mg
7-9yo=700mg
10-18yo=1000mg
- Ensure adequate Phosphate intake</td>
<td>- Promote Weight-bearing activities
- 24h postural management
- Review AFO and equipment needs
- Avoid prolonged immobilization after surgery.</td>
</tr>
</table>

Figure 2: Recommendations for managing a child with LTNC with osteoporosis*

Child with LTNC is assumed to have osteoporosis if one or more of the following is fulfilled:
• History of fragility fracture(s) • History of bone pain
1. Ensure adequate vitamin D and calcium with regular Dietitian review.
2. Order basic investigations:
- Calcium - Phosphate - Parathyroid hormone (PTH) - Alkaline phosphatase (ALP) - 25-hydroxyvitamin D (25-OH-D) - **X-ray** of 'symptomatic area' to assess possible fracture
3. Refer ENDOCRINE
- Consider bisphosphonates - Consider other investigations: **- Lateral spine X-ray** to assess for the presence of vertebral compression fractures - If child is more than 6yo, consider **DEXA scan for Lumbar spine & Total Body Less Head/ TBLH** (or distal lateral femur) - Use Z-score adjusted for age, sex and height - Follow-up DEXA scan every 6-12months.
4. Refer ORTHOPAEDICS
- Immobilize fracture - Avoid prolonged immobilization after fracture - Advise physiotherapist on weight-bearing status and range of motion
5. Refer PHYSIOTHERAPY
- Non-weightbearing gentle stretch after acute fracture - After cast removal, gradual stretch and weight-bear as tolerated. - Discuss with orthopaedic surgeon and primary physician regarding intensity of exercises and stretch

*****A child is diagnosed with osteoporosis when he has a clinically significant fracture history and low BMD (ie. *BMD z-score less than −2.0* adjusted for age, gender, and body size).[29]

Table 1: Characteristics of study subjects with LTNC (N=136)		
Mean age (years)	11.4 ± 6.7	
Gender	Male Female	85 (62.5%) 51 (37.5%)
Race	Chinese Malay Indian	94 (69.1%) 31 (22.8%) 11 (8.1%)
GMFCS	III IV V	21 (15.4%) 27 (19.9%) 88 (64.7%)
Type of LTNC	Cerebral palsy DMD Neuro-genetic disorder Brain tumor Others	90 (66.2%) 7 (5.1%) 26 (19.1%) 0 15 (11.0%)
Dominant motor feature	Spastic Dyskinetic Mixed spastic-dyskinetic Hypotonic Ataxic	50 (36.8%) 40 (29.4%) 20 (14.7%) 24 (17.6%) 2 (1.5%)
Number of patients with weight measured		131 (96.3%)
Number of patients with height measured		92 (67.6%)
Mean weight SDS Mean height SDS		-3.11 -2.73
Underweight, n (%) (weight z-score for age/ gender less than -2 SDS)		81 (60.0%)
Height z-score for age/ gender less than -2 SDS		63 (46.3%)
Type of feeding, n (%)	PEG/ NGT feeding Blended oral diet Normal oral diet	40 (29.4%) 41 (29.4%) 55 (41.2%)
Lack of regular weight-bearing, n (%)		101 (74.3%)
Number of patients on anti-convulsant		80 (58.8%)
Number of patients on steroids		7 (5.1%)
Number of patients with serum albumin measured		65 (47.8%)

Mean serum albumin (g/L)	36
Number of patients with measured calcium levels	45 (33.1%)
Number of patients on calcium supplements	10 (7.6%)
Number of patients with measured Vitamin D levels	10 (7.4%)
Mean vitamin D level (ng/ml)	27.5
Number of patients on Vitamin D supplements	32 (23.5%)

Table 2: Fracture characteristics (N=15)

Location of fracture	Upper limb: Clavicle Humerus	 1 (6.7%) 3 (20.0%)
	Lower limb: Femur	 11 (73.3%)
Mechanism of fracture	During transfer During dressing/care During sleep After stretching After self- arching Unknown	5 (33.3%) 2 (13.3%) 3 (20.0%) 2 (13.3%) 1 (6.7%) 2 (13.3%)

Table 3: Characteristics of children with fragility fractures (N=15)			
	Total (N=15)	Site of fracture	
		Upper limb (n=4)	Lower limb (n=11)
Gender			
Male, n (%)	12 (80.0%)	4 (100%)	8 (72.7%)
Female, n (%)	3 (20.0%)	0 (0%)	3 (27.3%)
Race, n (%)			
Chinese	9 (60.0%)	3 (75.0%)	6 (54.5%)
Malay	2 (13.3%)	0 (0%)	2 (18.2%)
Indian	3 (20.0%)	1 (25.0%)	2 (18.2%)
Other	1 (6.7%)	0 (0%)	1 (9.1%)
Type of LTNC, n (%)			
Cerebral palsy	7 (46.7%)	2 (50.0%)	5 (45.5%)
DMD	3 (20.0%)	2 (50.0%)	1 (9.1%)
Neuro -genetic disorder	4 (26.7%)	0 (0%)	4 (36.3%)
Brain tumour	1 (6.7%)	0 (0%)	1 (9.1%)
Dominant Motor Feature, n (%)			
Spastic	1 (6.7%)	0 (0%)	1 (9.1%)
Dyskinetic	6 (40.0%)	2 (50.0%)	4 (36.3%)
Mixed Spastic-dyskinetic	4 (26.7%)	1 (25.0%)	3 (27.3%)
Hypotonic	4 (26.7%)	1 (25.0%)	3 (27.3%)
Ataxic	0 (0%)	0 (0%)	0 (0%)
GMFCS V, n (%)	15 (100%)	4 (100%)	11 (100%)
Underweight, n (%)	12 (80.0%)	3 (75.0%)	9 (81.8%)
Type of feeding, n (%)			
PEG/ NGT feeding	6 (40.0%)	0 (0%)	6 (54.5%)
Oral modified diet	9 (60.0%)	4 (100%)	5 (45.5%)
Lack of regular weight-bearing, n (%)	14 (93.3%)	4 (100%)	10 (90.9%)
Number of patients on anti-convulsant	6 (40%)	1 (25%)	5 (45.4%)
Number of patients on steroid	3 (20%)	1 (25%)	2 (18.2%)
Number of patients with serum albumin levels measured	11 (73.3%)	3 (75%)	8 (72.7%)
Mean serum albumin (g/L)	31.7		
Number of patients with calcium levels measured	8 (53.3%)	1 (25%)	7 (63.6%)
Number of patient on calcium supplementation	4 (26.7%)	0	4 (36.4%)
Number of patients with Vitamin D levels measured	8 (53.3%)	0	8 (72.7%)
Mean vitamin D level (ng/ml)	19.9		
Number of patients on Vitamin D supplementation			
Before fracture:	1 (6.7%)	0	1 (9.1%)
Started after fracture:	11 (73.3%)	3 (75%)	8 (72.3%)