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Research Article

The Role of Obesity on Cast Index and Secondary Intervention in Pediatric Forearm Fractures

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Abstract

Background: Pediatric forearm fractures are common, and the majority are treated with closed reduction and immobilization. Additionally, the incidence of pediatric obesity is rising. Cast index is a useful metric to assess the quality of a cast mold. This study aims to assess the effect of obesity in obtaining an adequate cast index as a predictor for fracture redisplacement and risk for subsequent intervention after a reduction.

Methods: A retrospective chart review was conducted over a six-year time period on children with a displaced/unstable forearm fracture that underwent reduction and molded long arm casting with >4 weeks follow-up. The cast index was measured on immediate post-manipulation radiographs. Children were divided into three groups according to body mass index (BMI) percentile for age: Underweight (<5th); Normal BMI (5th-85th); Overweight/obese (≥ 85th). Clinical notes and radiographs were reviewed for loss of reduction and secondary intervention.

Results: 84 patients (70% male) qualified for inclusion. Mean age was 7.4 years (Range 3-14 years). Fracture redisplacement and secondary intervention occurred in 8 patients (9.5%). Patient BMI distribution was 5% in the Underweight, 71% in the Normal BMI and 24% in the Overweight/obese groups. The mean cast index in the 8 patients who required a second procedure was significantly higher than those who did not (1.00±0.06 vs 0.83±0.07, P<.001). The mean cast index among the underweight, normal BMI and overweight/obese groups was not statistically different. Obesity was not an independent risk factor for secondary

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intervention. Regression analysis did not correlate increasing cast index with BMI percentile for age.

Conclusion: Cast index continues to be reliable metric for evaluating the quality of the cast mold and loss of subsequent reduction. In this cohort, it does not appear that BMI plays a significant role in hindering the ability to place a well-molded cast.

Level of Evidence: Prognostic level IV

Keywords

Pediatric; Forearm Fracture, Obesity, Cast Index

Introduction

Recent data highlights that pediatric obesity is on the rise, with reports from the Center for Disease Control and Prevention (CDC) stating that obesity has more than tripled since the 1970s [1]. Now, nearly 30% of children age two to nineteen are considered either overweight or obese [2,3]. Furthermore, a child's overall fracture risk and severity are directly correlated to increased Body Mass Index (BMI) [4-6]. As forearm fractures are one of the most common injuries in the pediatric population, understanding the impact of obesity on management of forearm fractures is imperative [7-10].

The management of pediatric forearm fractures depends on the age of the patient and magnitude of deformity. Treatment options include non-operative management with closed reduction and immobilization versus operative treatment with stabilization. Most closed pediatric forearm fractures can be treated with closed reduction and placement of a well-molded cast or splint. Operative treatment should be reserved for patients in whom satisfactory alignment cannot be achieved or maintained through closed means [7,10-13].

Loss of reduction is the most common complication following closed treatment of pediatric forearm fractures. Poor casting technique is a frequently cited reason for loss of reduction and subsequent occurrence of further intervention [7,10,14-16]. Principles of forearm casting include interosseous molding, supracondylar molding, appropriate padding, evenly distributed cast material, straight ulnar border, and three-point molding [10]. Furthermore, the Cast Index (CI) is a useful metric to objectively assess cast quality. The cast index is calculated from plain radiographs as the sagittal cast width divided by the coronal cast width at the fracture site, as measured from the inner surface of the cast [15,17,18]. An acceptable CI has previously been described as a ratio <0.70, but has also been reported as high as <0.84 [7,17-20].

The concern regarding a rising population of overweight and obese children is the consequent thicker soft tissue envelope surrounding the osseous structures of the forearm and therefore,

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the theoretical difficulty with obtaining an appropriate mold, as evidenced by the CI. This study aims to assess:

1. The ability of CI to predict subsequent intervention after closed reduction and casting

2. The effect of obesity on obtaining an adequate CI

3. If obesity is an independent risk factor for failed initial closed reduction and casting

Materials and Methods

After approval by our Institutional Review Board, we retrospectively reviewed the radiographs of all angulated and/or displaced pediatric forearm fractures that underwent closed reduction with long arm fiberglass cast application at a tertiary care pediatric academic medical center over a 6-year period (2011-2016). Skeletally immature patients less than 16 years of age qualified for inclusion. Exclusion criteria included pathologic or open fractures, incomplete data or radiographs, and forearm fractures not treated with molded above elbow cast after manipulation.

All initial injury radiographs were assessed for angulation and displacement. All reductions were performed in the pediatric emergency department under sedation utilizing portable fluoroscopy. Following placement of a long arm bi-valved cast with the elbow in approximately 85-90° of flexion, post-reduction films were obtained. The reduction was deemed satisfactory when there was no evidence of displacement (i.e <5 mm) in both planes and angulation was corrected to acceptable parameters. All patients followed up in clinic 1 week after manipulation and then every 1-2 weeks for a minimum of 4 weeks.

Charts were retrospectively reviewed for demographic data consisting of age, gender, height, weight, bones involved, location and outcome data including loss of reduction and whether secondary intervention was undertaken. For purposes of this study, the cast index was measured on the immediate post-reduction bi-valved cast films. CI was measured as ratio a/b in which 'a' is the internal cast width in the lateral view and 'b' is the internal cast width in the AP view at the fracture site [12]. We also stratified the patients into groups based on their BMI percentile for age, as follows: Underweight (<5th %ile); Normal BMI (5th-85th %ile); Overweight/obese (≥85th %ile). The decision to proceed with secondary intervention was determined based on individual surgeon preference and interpretation of well-established guidelines [12,13,17,29].

Interobserver variation was determined by having two authors independently calculate the CI in our data set. Intra-observer variability was determined by having one of the author's repeat CI calculations of the data set 4 weeks after initial measurement. We used the Pearson correlation coefficient to determine correlation. The mean CI in the group requiring secondary procedures and the weight stratified groups were recorded and compared. The primary variable

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of interest was the BMI percentile for age and the main outcomes were CI and secondary intervention due to redisplacement. Paired, two-tailed student's t-tests were performed to analyze statistical differences between means in the groups of continuous data; $p<0.05$ was deemed significant. For categorical data, the Chi-square test was used. Statistical analysis was performed using IBM SPSS® software v. 24 (Chicago, Illinois).

Results

Over our study period, we identified 84 patients who met inclusion criteria with displaced and/or angulated forearm fractures that underwent closed reduction and long arm casting. Mean age was 7.4 years (range 3-14years), and 59 (70%) were male. After stratifying the children into weight groups based on BMI percentile for age, 4 were in the underweight category (5%), 60 were in the normal weight category (71%), and 20 were in the overweight/obese category (24%). The mean cast index for the study group was 0.86±0.01 (range 0.63-1.18). The mean cast index among the underweight, normal weight, and overweight/obese groups were not found to be statistically different (Table 1). Additionally, regression analysis did not show that increasing BMI percentile for age was an independent risk factor for increased CI.

Occurrence of secondary intervention occurred in a total of 8 patients (9.5%): 6/59 males and 2/25 females. The mean cast index in these 8 patients who required a second procedure was 1.00±0.06, which was significantly higher than the mean cast index in the children who did not have a secondary procedure (0.83±0.07, $p<0.001$, Table 2). Of these 8 patients requiring secondary intervention, 3 underwent repeat closed reduction in the operating room, 3 underwent elastic nailing, and 2 underwent open reduction and internal fixation (Table 3). A representative example of a patient who a poor cast index that ultimately re-displaced and required flexible nailing is shown in Fig. 1. All secondary interventions were performed between 1 and 3 weeks of initial injury.

Mean initial angulation for all fractures was 25º. The mean initial angulation for patients requiring a secondary intervention was 18.78º as compared to 25.71º in group that did not require re-intervention, which was not statistically significant ($p>0.05$, Table 2).

Pearson's correlation coefficient was used to compare repeat measurements to original measurements. Analysis of both inter and intra-observer measurements showed high agreement and that CI could be reproduced reliably. There was good intra-observer ($r=0.98$) and inter-observer ($r=0.93$) agreement for the CI in the study group and the observed differences were less than two standard deviations in magnitude.

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	Underweight	Normal	Overweight/Obese	P
Number	4	60	20	-
Mean CI	0.83	0.87	0.85	NS
CI: Cast Index; NS: Not Significant				

Table 1: Cast index by BMI percentile for age.

Factor	No 2nd Intervention Group	2nd Intervention Group	P-Value
Mean Age (years)	7.21	9.38	NS
Gender	53M : 23F	6M : 2F	NS
Initial Mean Angulation (˚)	25.71	18.78	NS
Mean Redisplacement (˚)	4.43	15.76	<0.001
Mean CI	0.83	1	<0.001
CI: Cast Index; NS: Not Significant			

Table 2: Patients with no secondary intervention vs. with secondary intervention.

Age (years)	Gender	Location/Type	BMI %ile	Cast Index	2nd Intervention*
13	M	MBB	15.9	0.96	EN
14	M	MBB	16	1.11	ORIF
9	M	DBB	19.4	0.98	CR
9	M	PBB	50.3	0.97	CR
7	M	MBB	56.5	0.97	CR
4	F	PBB	56.6	0.99	EN
6	F	PBB	75	0.93	EN
13	M	MBB	91.8	1.09	ORIF
MBB: Midshaft Both Bone; DBB: Distal Both Bone; PBB: Proximal Both Bone; En: Elastic Nails; ORIF: Open Reduction Internal Fixation; CR: Closed Reduction in operation room					
*All secondary intervention was within 1-3 weeks of initial injury					

Table 3: Summary of patients with secondary intervention.

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Figure 1: Case of a 6 year old female (BMI percentile 75, normal) who sustained a proximal both bone forearm fracture and underwent closed reduction and casting with a cast index of 0.93 (a, b). Ultimately, the fracture re-displaced (c,d) and required placement of elastic nail (e,f).

Discussion

While the health effects of childhood obesity are commonly linked to the cardiovascular and endocrine systems, providers must be aware of the relationship of obesity to pediatric musculoskeletal health. Risk of fracture secondary to low-impact trauma is greater in obese children and has been associated with lower bone density, poor diet, sedentary lifestyle, and greater propensity to fall due to altered gait mechanics and poor balance [6,21-25]. Previous metabolic and biomechanical studies have shown that excess fat accumulation impedes skeletal development and increases the peak force transmitted through an arm during a fall, thus contributing to increased fracture incidence amongst obese children [23,25].

Although there is significant variability in what truly defines loss of reduction in the literature, rates are cited anywhere from 7.3% to 32.3%, which encompasses all variations of pediatric

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forearm fractures [4,7,16,18,21,26-30]. In the present study, we defined loss of reduction as any redisplacement that resulted in secondary intervention based on surgeon discretion. This definition yielded a secondary intervention rate of 9.5% amongst all our patients.

Predictors of loss of reduction include older age, lack of anatomic reduction immediately post-manipulation magnitude of deformity at the time of fracture, initial magnitude of displacement, more proximal fractures and poor casting technique as evidenced by the cast index, Canterbury index, padding index, or 3-point index [4,16,26-30]. Furthermore, we chose to evaluate the Cast Index (CI) as it has the advantage of being easy to perform, quick, and reproducible, with concomitantly high inter- and intra-observer reliability [18]. The CI is, in essence, a marker for a well-molded cast.

Chess et al., initially described the cast index in 1994 in a population of 761 fractures. These authors found that re-angulation at follow-up was related to poor cast molding, as reflected by a high cast index, set at 0.70 based on previous anthropometric studies [15]. Subsequent studies have examined the utility of the cast index as a predictor of loss of reduction and have yielded similar results [16-19]. Debnath et al., calculated the mean CI for patients that required a secondary intervention was 0.92±0.08 as compared to 0.77±0.07 for the patients that did not require secondary intervention [17]. Kamat et al., found that in patients with CI <0.8, the displacement rate was 5.58% whereas in patients with CI >0.81, the displacement rate was 26% [18]. We found that the mean cast index in our patients that required a secondary intervention was significantly higher than those who did not (1.00±0.06 vs 0.83±0.07, P<.001), independent of both BMI and magnitude of initial deformity.

Over further detail in the aforementioned studies is the effect of a patient's weight on the adequacy of cast application. For instance, Debnath et al., found higher CI in patients aged <5 and >10 and owed it to the fact that these age groups have excess subcutaneous fat and therefore increased difficulty with cast molding [17]. In a similar fashion, Kamat et al., noted the lack of inclusion of patient weight measurements as a potential weakness in their study [18]. The results of our present study disprove the idea that subcutaneous fat inhibits an adequate reduction as we found no significant difference in CI amongst the underweight, normal BMI, and overweight/obese groups. Additionally, regression analysis did not correlate increasing cast index with BMI percentile for age.

Our study has several limitations, including those inherent to retrospective reviews, lack of long-term follow-up, and relatively small sample size. Additionally, we chose to include in this study all fractures broadly categorized as forearm fractures, which included isolated radius or ulna fractures or both bone fractures at any level, which could result in differing results if these were analyzed separately. Finally, the initial reductions were performed by multiple orthopedic residents of varying skill levels thereby possibly affecting the quality of reduction and cast molding.

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Conclusion

In conclusion, we found that cast index is both a reproducible and reliable method of objectively critiquing a cast and ultimately of predicting failure of treatment. The mean cast index for patients who required secondary intervention was significantly higher than those patients that did not require secondary intervention (P<.001). Additionally, we found that obesity does not preclude a well-molded cast with an acceptable cast index and moreover is not an independent risk factor for failed closed reduction.

References

1. Fryar CD, Carroll MD, Ogden CL. Prevalence of overweight and obesity among children and adolescents: United States, 1963-1965 Through 2011-2012. Center for Disease Control and Prevention. 2014.

2. Skinner AC, Perrin EM, Skelton JA. Prevalence of obesity and severe obesity in US children, 1999-2014. Obesity (Silver Spring, Md). 2016;24(5):1116-23.

3. Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of obesity among adults and youth: United States, 2015-2016. NCHS Data Brief. 2017;(288):1-8.

4. DeFrancesco CJ, Rogers BH, Shah AS. Obesity increases risk of loss of reduction after casting for diaphyseal fractures of the radius and ulna in children: an observational cohort study. J Ortho Trauma. 2018;32(2):e46-51.

5. Kwan C, Doan Q, Oliveria JP, Ouyang M, Howard A, Boutis K. Do obese children experience more severe fractures than nonobese children? A cross-sectional study from a paediatric emergency department. Paediatrics & Child Health. 2014;19(5):251-5.

6. Valerio G, Gallè F, Mancusi C, Di Onofrio V, Guida P, Tramontano A, et al. Prevalence of overweight in children with bone fractures: a case control study. BMC Pediatrics. 2012;12(1):166.

7. Vopat ML, Kane PM, Christino MA, Truntzer J, McClure P, Katarincic J, et al. Treatment of diaphyseal forearm fractures in children. Ortho Rev. 2014;6(2):5325.

8. Ryan LM, Teach SJ, Searcy K, Singer SA, Wood R, Wright JL, et al. Epidemiology of pediatric forearm fractures in Washington, DC. J Trauma Injury, Infection and Critical Care. 2010;69(4):S200-5.

9. Chung KC, Spilson SV. The frequency and epidemiology of hand and forearm fractures in the United States. J Hand Surg. 2001;26(5):908-15.

10. Flynn JM, Skaggs DL, Waters PM. Rockwood and Wilkins' fractures in children. Philadelphia: Wolters Kluwer Health. Ed.8th. 2015.

11. Flynn JM, Jones KJ, Garner MR, Goebel J. Eleven years experience in the operative management of pediatric forearm fractures. J Pediatric Ortho. 2010;30(4):313-9.

12. Franklin CC, Robinson J, Noonan K, Flynn JM. Evidence-based medicine: management of pediatric forearm fractures. J Pediatric Ortho. 2012;32(2):131-4.

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13. Truntzer J, Vopat ML, Kane PM, Christino MA, Katarincic J, Vopat BG. Forearm diaphyseal fractures in the adolescent population: treatment and management. Euro J Ortho Surg Traumatol Ortho Traumatolo. 2015;25(2):201-9.

14. Younger AS, Tredwell SJ, Mackenzie WG. Factors affecting fracture position at cast removal after pediatric forearm fracture. J Pediatric Ortho. 1997;17(3):332-6.

15. Chess DG, Hyndman JC, Leahey JL, Brown DC, Sinclair AM. Short arm plaster cast for distal pediatric forearm fractures. J Pediatric Ortho. 1994;14(2):211-3.

16. Bhatia M, Housden PH. Redisplacement of paediatric forearm fractures: Role of plaster moulding and padding. Injury. 2006;37(3):259-68.

17. Debnath UK, Guha AR, Das S. Distal forearm fractures in children: Cast index as predictor of re-manipulation. Indian J Orthop. 2011;45(4):341-6.

18. Kamat AS, Pierse N, Devane P, Mutimer J, Horne G. Redefining the cast index: the optimum technique to reduce redisplacement in pediatric distal forearm fractures. J Pediatric Ortho. 2012;32(8):787-91.

19. Webb GR, Galpin RD, Armstrong DG. Comparison of short and long arm plaster casts for displaced fractures in the distal third of the forearm in children. J Bone Joint Surg Am. 2006;88(1):9-17.

20. Alemdaroğlu KB, Iltar S, Cimen O, Uysal M, Alagöz E, Atlihan D. Risk factors in redisplacement of distal radial fractures in children. J Bone Joint Surg Am. 2008;90(6):1224-30.

21. Okoroafor UC, Cannada LK, McGinty JLDoOSSLUSLMO. Obesity and Failure of Nonsurgical Management of Pediatric Both-Bone Forearm Fractures. J Hand Surg. 2017;42(9):711-6.

22. Dimitri P, Wales JK, Bishop N. Fat and bone in children: Differential effects of obesity on bone size and mass according to fracture history. J Bone and Mineral Res. 2010;25(3):527-36.

23. Paul D. Fat and bone in children - where are we now? Ann Pediatric Endocrinol Metabolism. 2018;23(2):62-9.

24. Kim SJ, Ahn J, Kim HK, Kim JH. Obese children experience more extremity fractures than nonobese children and are significantly more likely to die from traumatic injuries. Acta Paediatrica. 2016;105(10):1152-7.

25. Davidson PL, Goulding A, Chalmers DJ. Biomechanical analysis of arm fracture in obese boys. J Paediatr Child Health. 2003;39(9):657-64.

26. Haddad FS, Williams RL. Forearm fractures in children: avoiding redisplacement. Injury. 1995;26(10):691-2.

27. Bowman EN, Mehlman CT, Lindsell CJ, Tamai J. Nonoperative treatment of both-bone forearm shaft fractures in children: predictors of early radiographic failure. J Pediatric Ortho. 2011;31(1):23-32.

28. Franklin CC, Wren T, Ferkel E, Arkader A. Predictors of conversion from conservative to operative treatment of pediatric forearm fractures. J Pediatric Ortho. 2014;23(2):150-4.

29. Hang JR, Hutchinson AF, Hau RC. Risk factors associated with loss of position after closed reduction of distal radial fractures in children. J Pediatric Ortho. 2011;31(5):501-6.

30. Zamzam MM, Khoshhal KI. Displaced fracture of the distal radius in children factors responsible for redisplacement after closed reduction. J Bone and Joint Surg. 2005;87(6):841-3.

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