CAST VERSUS WIRE FIXATION IN DISPLACED DISTAL RADIUS FRACTURES IN CHILDREN : OUTCOMES AT SKELETAL MATURITY

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TABLE OF CONTENTS

ABSTRAK

Pengenalan: Anjakan selepas penarikan tulang merupakan satu komplikasi lazim sepanjang tempoh simen kas pada kanak-kanak yang pernah dirawat untuk kepatahan tulang radius distal. Penstabilan kepatahan dengan penetapan dawai juga digunakan untuk mengekalkan penarikan tulang semasa proses penyembuhan. Namun, komplikasi juga boleh terjadi. Kami menilai hasil klinikal dan radiologi pada kematangan kerangka tulang bagi kanak-kanak yang mengalami kepatahan tulang radius distal yang pernah dirawat dengan simen kas sahaja atau penetapan dawai.

Metodologi: Satu kajian retrospektif terhadap 57 pesakit kepatahan tulang radius distal kawasan metafisis dan fisis telah dijalankan. Daripada 30 pesakit kepatahan metafisis, 19 dirawat dengan simen kas manakala 11 dengan dawai. 19 daripada 27 pesakit kepatahan fisis dirawat dengan simen kas manakala lapan dirawat dengan dawai. Kesemuanya telah dinilai secara klinikal dan radiologi semasa atau selepas kematangan kerangka tulang pada purata 6.5 tahun rawatan susulan (3.0 kepada 9.0 tahun).

Keputusan: Dalam kumpulan metafisis, pesakit yang dirawat dengan penetapan dawai hanya mempunyai palmarfleksi pergelangan tangan yang lebih terhad ($p=0.04$) namun dalam kumpulan fisis, pergerakan terhad didapati pada kedua-dua dorsiflexi ($p=0.04$) dan palmarfleksi ($p=0.01$) apabila dibandingkan dengan pergelangan tangan kontralateral. Dalam kumpulan fisis, terdapat perbezaan signifikan secara statistik dalam kecenderungan radial ($p=0.01$) dan kecondongan dorsal ($p=0.03$) antara simen kas dan penetapan dawai. Tiada perbezaan dari sudut radiologi didapati dalam kumpulan metafisis. Kesemua pesakit tidak mengalami kesakitan kecuali seorang (5.3%) dari kumpulan fisis yang mempunyai kesakitan ringan. Tiada perbezaan statistik pada kekuatan genggaman dalam semua kumpulan. Komplikasi dawai termasuk bantutan fisis radial dan ulna, jangkitan kawasan pin dan kekebasan.

Kesimpulan: Simen kas dan penetapan dawai menunjukkan hasil yang cemerlang dan baik pada kematangan kerangka tulang kanak-kanak yang mengalami kepatahan tulang radius distal metafisis dan fisis. Lokasi kepatahan dan jenis rawatan tidak mempengaruhi kekuatan genggaman pada kematangan kerangka tulang.

Katakunci;

Radius distal, metafisis, fisis, penetapan dawai, pediatrik, pembentukan semula tulang

ABSTRACT

Introduction: Displacement following fracture reduction was a common complication during casting period in children previously treated for the distal radius fracture. Fracture stabilization with wire fixation was also used to maintain the reduction during fracture healing, but not without complications. We evaluated the clinical and radiological outcomes at skeletal maturity of distal radius fractures in children previously treated either with cast alone or with wire fixation.

Methodology: A retrospective study of 57 patients with both metaphyseal and physeal fractures of distal radius was conducted. Out of 30 patients with metaphyseal fractures, 19 were in cast group and 11 were in wire group. Nineteen out of 27 patients with physeal fractures were from cast group while eight were from wire group. All were evaluated clinically and radiologically at or after skeletal maturity at the mean follow up of 6.5 years (3.0 to 9.0 years).

Results: In metaphysis group, patients treated with wire fixation had more restriction in wrist palmarflexion (p=0.04) only but in physis group, more restriction of motion was found in both dorsiflexion (p=0.04) and palmarflexion (p=0.01) when compared to contralateral wrist. In physis group, there was a statistically significant difference in radial inclination (p=0.01) and dorsal tilt (p=0.03) between cast and wire fixation. No radiological difference was found in metaphysis group. All patients were pain free except one (5.3%) in physis group who had only a mild pain. Grip strength showed no statistical difference in all groups. Complications of wire included radial and ulnar physeal arrests, pin site infection and numbness.

Conclusions: Cast and wire fixation showed excellent and good outcomes at skeletal maturity in children with previous distal radius fracture involving both metaphysis and physis. Site of fracture and type of treatment subjected have no influence on the grip strength at skeletal maturity.

Keywords;

distal radius, metaphysis, physis, wire fixation, paediatric, remodeling.

Chapter 1

INTRODUCTION

1.1 INTRODUCTION

Incidence

The distal radius fractures attribute to 20-35% of paediatric fractures(1-3). Of these, metaphyseal and physeal fracture comprised of 20.2% and 15%, respectively(4, 5). In other study by Peterson et al (6), incidence of distal radial physis injury is reported up to 29.6% and most are Salter Harris Type II (7). In addition, the associated distal ulnar fracture is reported approximately 56% (8). Nevertheless, the incidence has been recently reported to be increasing with age and more prevalent in boys after age 8 years(9), attributed to accelerated growth during puberty(10).

Mechanism of injury

Most of injury occurs due to fall from low-energy trauma (1, 9, 11, 12), approximately 50% of cases and it occurs at home, followed with injury at playground or contact activities (9, 12). Motor-vehicle accident only accounts for 7.9% (9).

Current Practice

The management of distal radius fracture in children depends on the displacement of the fracture. Non-displaced or minimally displaced fracture does not require any reduction and is immobilized either with cast or splint for short period of 4 to 6 weeks with excellent functional outcomes (13, 14). Whereas, displaced distal radius fracture requires reduction with or without stabilization with wire and immobilization with an above-elbow cast for at least 4 weeks (8, 15, 16). However, re-displacement is the most common complication of casting following successful initial reduction, ranging from 7% to 39% (16-21) and about 43.7% required secondary manipulation (22).

Acceptable Angulation

Another dilemma during non-operative management of distal radius fracture in children is the variability of acceptable re-angulation of fracture fragments. The controversial exists in term of deciding whether to accept the re-angulation without subjecting the patient to a secondary manipulation with or without stabilization with wire fixation. With the inherent ability of remodeling possessed by young children as long as the physis is still opened (23, 24), we can accept more degree of angulation with the expectation that the angulation will be corrected as the child grows and ultimately leads to no functional limitations. In earlier study by Do et al. (23), they accepted angulation less than 15 degrees in any direction and shortening of 1cm as it subsequently achieved complete remodeling of residual angulation within an average of 7.5 months without functional impairment. Mani et al. (20) suggested that angulation exceeding 15 degrees regardless of direction or bayonetting of fragments was unacceptable. Zimmermann et al. (25), in their long-term study of 10 years follow up, found that children aged more than 10 years with residual angulation of more than 20 degrees had worst functional outcomes. The findings by Zimmermann et al. (25) also corroborated suggestion by Noonan and Price (26), in which angulation less than 20 degrees in distal radius fracture will frequently undergo remodelling. Zamzam et al. (18) in his retrospective study stated that angulation more than 20 degrees or apposition of less than 50% between fragments required remanipulation. Subsequent study by Planka et al. (24) found that angulation up to 30 degrees did not require secondary manipulation, especially in age less than 12 years old, because majority had complete remodelling. Roth et al. (27), in retrospective study, agreed with findings by Planka et al. (24), in which he demonstrated that up to 30 degrees angulation can be tolerated in age less than 9 years, 25 degrees in between 9 to 12 years, and 20 degrees in age more than 12 years. Based on this finding, they did not recommend any secondary manipulation to correct the mal-aligment. Although remodeling potential is remarkable in younger age, any union in mal-rotated position is not well tolerated as the rotation does not remodel (28). However, Noonan and Price (26) accepts mal-rotation up to 45 degree in age less than 9 years and up to 30 degrees in age more than 9 years.

Risk Factors for Redisplacement

Redisplacement is the most common complications of casting (16-21); many authors analyzed and described significant risk factors for redisplacement so that early intervention can be taken up to prevent unacceptable redisplacement leading to functional limitations. Redisplacement was defined by Proctor et al. (29) as re-displacement or re-angulation of fracture more than 20 degrees or loss of contact about 50% between the fragments. In other definition, Roth et al. (27) stated that re-angulation was angulation exceeding 15 degrees on either coronal or sagittal view of radiograph. Proctor et al. (29) divided risk of redisplacement into three main categories; patient-related factors, fracture-related factors and treatment-related factors. Patient-related factors include reduction of soft tissue swelling within the cast and muscle wasting during casting period (30). However, age (17, 29), ethnic, sex, and cause of injury (29) did not associate with redisplacement. For fracture-related factors, the most significant risk factors were complete displacement of fracture at initial injury (18, 21, 29, 31-33). Choi et al. (31), Nietosvaara et al. (34) and Mani et al. (20) described that more than 50% translation was considered high risk for redisplacement. Apart from complete displacement at initial injury, Alemdaroglu et al. (32) and Hang et al. (33) described obliquity of fracture was other significant risk factors. Associated distal ulnar fracture also contributed to redisplacement as suggested by Zamzam et al. (18) and Hand et al (33). For treatment-related factors, imperfect anatomical reduction (21, 29, 31, 33) was the most important risk factor for redisplacement. Other risk factors include type of sedation during reduction (18), improper moulding of the cast (17) and surgeon's experience in reduction techniques (21). However, Luscombe et al. (35) stated that quality of initial reduction had no effect on redisplacement.

Wire Fixation

Several authors recommended wire fixation in patients with high risk for redisplacement in order to maintain satisfactory reduction during the fracture healing(18, 29, 31, 34). Proctor et al. (29) recommended wire fixation in patients with imperfect reduction. Choi et al. (31) performed immediate wire fixation in age less than 16 years with high risk for redisplacement, that is loss of contact more than 50% between fragments, and found that only 9 (6.4%) of 140 children had loss of reduction. Zamzam et al. (18) also suggested immediate wire fixation to be performed in fracture with complete displacement, even in the case with adequate closed reduction. In patients reaching skeletal maturity, Nietosvaara et al. (34) suggested for wire fixation in patients with high risk of redisplacement. Similarly, Van Leemput et al. (15) and Hang et al. (33) recommended primary wire fixation in unstable distal radius fracture (15), complete initial redisplacement, associated distal ulnar fracture, and imperfect reduction (33) because it maintained reduction until fracture healing.

Based on findings from prospective study, McLauchlan et al. (36) also advocated wire fixation to maintain reduction in fracture with complete displacement. However, Luscombe et al. (35) evaluated their institutional protocol for selective wiring for unstable displaced distal radius fracture and found that wiring did not alter rate of redisplacement and secondary manipulation.

Outcomes of Cast Alone vs Wire Fixation

Many studies were performed to determine the outcomes of each intervention in treatment of distal radius fracture. The short and long term functional outcomes were generally acceptable. Ramoutar et al., (12) in a retrospective review of 248 metaphyseal distal radius fractures who had manipulation and fixation with wire with short follow up of median 6.6 weeks, found that 87% had no functional deficit, 10% had mild functional limitation, 2% moderate functional limitation and 1% severe functional limitation. They also noted that decreased in functional outcomes was associated with angulation exceeding 15 degrees when comparison made with angulation less than 15 degrees (12). Similarly, in a prospective randomized controlled trial by McLauchlan et al. (36) on 56 metaphyseal distal radius fractures comparing between manipulation with cast and manipulation with wire fixation, discovered that 7 out of 33 patient in manipulation and cast group had fracture healed with more than 20 degrees dorsal angulation and four of them had mean loss 7.5 degree of supination/pronation, 25 degree of flexion/extension and 14 degree of radial/ulnar deviation after 3 months follow up. They also reported one case in wire group that healed in more than 20 degrees dorsal angulation had restriction of 20 degrees of flexion and supination. However, there was no statistically significant difference between these two groups (36). Zimmermann et al. (25), in a retrospective study on long-term functional outcomes with follow up of median 10 years between palmarly and dorsally displaced distal radius fractures, reported that limitation in supination was significantly associated with palmarly displaced fracture but the capacity for remodelling both residual palmar and dorsal angulation were the similar (25). Similarly, Colaris et al. (37) evaluated 128 children prospectively between cast alone and cast with wire at mean follow up of 7.1 months and found that both groups had restriction in pronation and supination but wire group had statistically less restriction in forearm rotation (37). In a very long-term follow-up, Cannata et al. (38) studied on clinical and radiographic outcomes of 139 salter-harris type-2 fracture of distal radius in mean follow-up of 35.5 years and found that 5% limited motion of the wrist (which was due to radial shortening of more than 1cm), 1.4% had complaint of pain, and 2.9% had reduced grip strength (38, 39). Another long-term study by Houshian et al. (40) with median follow-up of 8.5 years on remodeling of salter-harris type fractures treated non-surgically, they reported only small number (4 out 85 patients) complained of non-specific wrist pain following heavy work or sport activity (40). Otherwise, all had normal wrist and forearm motion as well as grip strength. However, in this study, no specific details of the results were given for motion and grip strength (39).

There were few established studies stating positive clinical and radiological outcomes at a long-term follow up in both treatment groups; cast alone or additional wire fixation. In a prospective study, Miller et al. (16) investigated 25 out 34 patients at mean follow up of 2.8 years comparing group of cast alone with group of percutaneous wire fixation in displaced distal metaphyseal fractures. They reported that all patients had no functional deficit in term of motion, strength and pain. They also found that wire fixation maintained the alignment till union (16). Another study by Hove et al. (19) found similar findings as Miller et al. (16), in which 7 out of 12 patients, with angulation exceeding 15 degrees at union, had normal wrist motion, grip strength, and no growth arrest after 7 years follow up (19). In this study, a very small number of patients were reviewed in a long-term assessment. In a recent retrospective cohort study by Roth et al. (27), they evaluated on 66 patients with re-angulation exceeding 15 degrees with 24 had undergone secondary manipulation and 42 had conservative treatment only and had final review after a mean of 4 years follow up. They found both groups had no statistically significant difference in clinical and radiological outcomes with all final radiographs showed near-perfect alignment (27).

Remodelling Capacity

It is well established that younger children have significant ability for remodeling following fracture, especially aged less than 10 - 12 years (24, 25, 40). As the age increases reaching the skeletal maturity, the remodeling potential reduces (41). In the remodeling capacity of malunion of distal radius fracture, Friberg et al. (42) confirmed malangulation stimulate growth over epiphyseal plate to correct the residual angulation with mean radial correction of 0.9 degrees/month in dorsal-palmar direction and 0.8 degrees/month in radio-ulnar direction (42). Apart from that, complete remodeling was not achieved if angulation exceeding 20 degrees (43). In addition, Nietosvaara et al. (34) demonstrated residual angular correction occurs at rate of 1 – 2.7 degree/month. Similarly, Jeroense et al. (44) found overall average remodeling speed was 2.5 degrees/month. Do et al. (23), in their retrospective study on 34 metaphyseal fractures, reported complete remodeling was achieved in average 7.5 months for angulation less than 15 degrees in all directions and shortening less than 1 cm (23). In term of direction of residual angulation, Zimmermann et al. (25) concluded both dorsal and palmar malangulation underwent remodeling with the same capacity (25).

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Chapter 2

OBJECTIVES OF THE STUDY

Research Questions

1. Is there any difference in the outcomes at skeletal maturity of distal radial physeal fracture in children treated between cast and wire fixation?
2. Is there any difference in the outcomes at skeletal maturity of distal radial metaphyseal fracture in children treated between cast and wire fixation?
3. Is there any difference in the grip strength at skeletal maturity between physeal and metaphyseal fractures of distal radius in children?

Objectives

General Objective

1. To compare the outcomes of distal radial fracture in children at skeletal maturity treated between cast and wire fixation.

Specific Objectives

1. To compare the clinical and radiological outcomes of displaced distal radial physeal fracture in children at skeletal maturity treated between cast and wire fixation.
2. To compare the clinical and radiological outcomes of displaced distal radial metaphyseal fracture in children at skeletal maturity treated between cast and wire fixation.
3. To compare the grip strength at skeletal maturity between physeal and metaphyseal fractures of distal radius in children.