ISOLATED DISTAL RADIAL FRACTURES IN CHILDREN AGED 6 TO 15YEARS: INCIDENCE OF REDISPLACEMENT AFTER CASTING AS SEEN IN KENYATTA NATIONAL HOSPITAL

BY

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DECLARATION

This is to certify that this dissertation is my original work and has not been presented for a degree course in any other University.

SIGNATURE.................................... **DATE**.17-04-2007

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This is to certify that this study was undertaken under my guidance and supervision and that this book is submitted with my approval as the University supervisor.

SIGNATURE............................ **DATE**...20/4/07..........

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DEDICATION

I dedicate this dissertation to my wife Dr. Lydia Kinyuru and to my children, Roselee and Joe without whose encouragement and support it would have been more difficult to complete this work.

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I am grateful first and foremost to Almighty God in whose strength and guidance I have relied on in my life.

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I would also extend my gratitude to fellow colleagues who called me when the patients came for follow up in the fracture clinic.

I also acknowledge the Kenyatta National Hospital Ethical and Research Committee for giving me the permission to go a head.

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SUMMARY

Aim

The main aim of the study was to evaluate the incidence of redisplacement of distal radial fractures in children aged between 6 and 15 years and factors contributing to it at the Kenyatta National Hospital.

Methodology

This was a prospective study carried over eight months from the 22nd June 2005 to 28th February 2006.One hundred patients were recruited. The fracture was reduced by the plaster technicians, the usual personnel who reduce these fractures at casualty; reduction was acceptable if the dorsal or volar angulation was less than 20^0. The patients were then followed up in the fracture clinic in the next two weeks with another x-ray. It was determined at this point whether there was presence of healing or redisplacement. Redisplacement was regarded as the presence of dorsal volar angulation of greater than 20^0 or translation greater than 50%. The end point of the study was at week four, x-ray of the distal forearm either showed evidence of redisplacement or evidence of healing at week four in other remaining patients. The data was collected and entered into statistical package for social sciences (SPSS) 12.0 version.

It was analyzed using odds ratio, Fisher's exact test and Chi-square test where appropriate. The difference within the variables was taken to be significance if the p value was less than 0.05.

Results

One patient had fracture of both distal radial bones making the total number of fractures to be 101. Thirty-seven of which were female and thirty four sustained their fractures as a result of involvement in games. Ninety two fractures involved the metaphysis and nine were in the distal third of the radial diaphysis, sixty five were complete fractures while thirty two were torus and only four were greenstick fractures. Fifty nine were angulated (fifty eight dorsal and one volar) and forty two were non-angulated. There were fifty nine displacements, (fifty six dorsal, one volar and two bayonet apposition) and forty two non-displaced fractures. There were fifty one fractures with no translation of one fragment on the other, thirty five fractures having less than 50% translation and fifteen having greater than 50% translation. Fifty four fractures were judged to be as a result of bending forces and fifteen as a result of shear forces and thirty two as a result of compression forces. Ninety nine patients got below elbow cast while only one had above elbow. Twenty two patients were given analgesics/sedation at reduction while seventy eight had the reduction under no analgesia/ sedation.

At week two nine (seven patients did not turn up and two did not have check x- rays) patients were not accounted for; and at week four another nine patients (five did not turn up and four did not have check X rays) were not accounted for. At week two, thirteen fractures redisplaced and were remanipulated, and at week four two of the thirteen remanipulated at week two maintained their reduction but four other fractures which had not redisplaced at week two redisplaced making them fifteen all of whom were admitted for operative reduction.

In consideration of the whole population seen with isolated distal radial fractures, the incidence of redisplacement would be 14.1% at week two and 18.1 % at week four, but considered as a percentage to the complete and greenstick (which are the fractures at risk of redisplacement) it would be 20.3% at week two and 21.9% at week four. The determinants of redisplacement were; angulation with a p value of 0.021, translation with a p value of 0.009 , completeness of fracture with a p value of 0.004, displacement with a p value of 0.006 and imperfect reduction with p value of 0.003.

Conclusion

The incidence of redisplacement of isolated distal fracture in children 6-15 years as seen in this study is comparable to international figures. The factors contributing to redisplacement are completeness of the fracture, initial displacement, translation and imperfect reduction. These factors constitute risk factors to redisplacement of the complete fractures.

INTRODUCTION

Paediatric distal radius fractures are common injuries[1, 2], boys are more affected than girls[3, 4]. Isolated distal radial fractures can result from indirect trauma involving angular loading combined with rotational displacement. Fractures of the distal radius especially in children are classified by location, amount of cortical disruption, angulations and distal fragment displacement as opposed to various classifications proposed for adult Colle's fracture.

Traditionally these fractures have been treated by closed reduction and immobilization in a plaster cast, the cast applied could be below the elbow or above the elbow. None of which method used to cast has been shown by Gavin et al in 1994 to be of no significant different in there outcome provided they are well molded[5].

There are reports showing that maintenance of satisfactory alignment can be difficult and redisplacement and malunion have been described in a number of papers [2-5,] most of these literatures have been describing both ulna and radius and not radius on its own. Successful reduction and outcome has largely depended on the initial displacement, presence of ipsilateral ulnar fracture, amount of transilation, and type of analgesia the reduction is done under[6.]

The acceptable degree of residual deformity remains ill defined. Hughston[7] argues that since there is capacity to remodel in the distal radius, one should, in a child younger than ten years old accept a dorsal angulation of up to 30 –40 ^{0} but for the patients older than 14 years, one should use adult guideline, while others believe that greater than 10^{0} of angulation in 6-10 years is unlikely to correct [8, 9]. Others have argued that up to 20^{0} dorsal angulation of the distal radius fracture in less than 15 years is acceptable[1].

The objective of this study was to evaluate the incidence of redisplacement in isolated distal radius in children aged 6-15 years and the factors contributing to redisplacement as seen in Kenyatta National Hospital. It described the characteristics of patients with these fractures, the type of fractures encountered, their initial management, management at follow-up up to week four when evidence of healing is already set, and the rate of redisplacement.

LITERATURE REVIEW

ANATOMY

Gross

Several anatomic differences distinguish paediatric forearms from those of adults. The paediatric shafts are proportionately smaller, with narrow medullary canals and the metaphysis contain more trabecular bone derived from periosteum membranous bone formation and peripheral endochondral bone formation, the paediatric bones also tend to be plastic and not as stable as the adults making them harder to reduce in case of fracture. In addition, the periosteum in children is much thicker than in adults[10]; this feature can both hinder and help in the management of paediatric forearm fractures.

Normal Growth and Implications for Remodelling

Distal radial epiphyseal growth plate is responsible for 75% of growth and proximal for 25%. Ossification commences in the cartilaginous body at week seven intrauterine life, at birth the radius has cartilaginous ends and the body is a tube of bone containing red marrow. A centre of ossification appears in early childhood in each epiphysis, in the second year at the distal end and the fourth year at the proximal end. The distal physis fuses at eighteen years and is the growing end of radius[11] while proximal at sixteen years.

This is consistent with the often-made observation that distal fore arm fractures have greater potential for remodelling than do more proximal fractures [12]. This also contributes to the thinking of researchers who say that one could allow up to $30\text{-}40^0$ of angulation in the distal end especially in those younger than 8 years[7]. Additional remodelling can also be attributed to elevation of the thick osteogenic periosteum after fracture. Intramembraneous ossification by the periosteum will assist in rapid healing and subsequent remodelling of residual deformity.

PATHOPHYSIOLOGY

The peak incidence of distal radial fractures coincides with the peak growth velocity for children, because of the relative porosity of the bone during this time[13]. The metaphysis is more at risk due to the fact that it is made of more trabecular bone than the rest of the bone hence weaker. Dorsal displacement of the distal fragment may be disguised by soft tissue swelling. Nerve injury is more likely if the fracture is significantly angulated or if there is significant swelling at the fracture site. Mechanism of injury is a fall on the extended wrist. A simple fall may result in a non-displacement of the fragments, with forward momentum (as when, for example, the child in riding a bicycle or in ice skating) is more likely to produce a displaced fracture. There could be associated supracondlyar or scaphoid fractures that should be excluded by physical and radiological examination. For a good and proper management, it is important to have a basic understanding of the forces leading to these fractures and their displacements as reduction are often performed in the direction opposite to that of the initial injury.

Indirect trauma is the typical cause of these fractures and it occurs as a result of a fall on outstretched hand. Direct trauma may additionally account for open fractures, severely displaced fractures and those on the proximal forearm; Evans[14] described an indirect mechanism of axial compression force in varying directions and degrees of rotation, the latter accounts for different patterns of fragment angulation. The final degree of fragment displacement due to indirect trauma varies between greenstick and complete fractures, but the initial mechanism of injury is usually the same. In some cases the force is not sufficient to completely displace the fracture, and therefore a greenstick fracture results. Compression forces basically cause the torus fracture as discussed above whereas shear forces cause greenstick and complete fractures that are not displaced. Excessive bending forces give rise to the displacement of the distal fragment either on the dorsal side for supinated forearm and volar in pronated forearm. The major force is transmitted in the longitudinal axis through the bone.

Injury Pattern In Relation To Anatomy in Growing Bones

Immature bones have the ability to bow rather than break in response to force. A compressive force in a child will produce a torus fracture, also called buckle fracture instead of the impacted fractures that occur in adults. Torus fracture is as result of failure of the cortex on the side of compression while greenstick is as a result of failure of the cortex on the side of tension. In very young children neither cortex may break, producing bowing of the bone, referred to as plastic deformation

Torus fractures are usually non-displaced because of the strong intact periosteum and can be managed conservatively though reports of refracture are reported in some literature[9]. Greenstick fractures and complete fractures usually show compression of the dorsal cortex and apex volar angulation; hence they risk late redisplacement or reangulation .

The junction between the diaphysis and the metaphysis is a point of decreased strength in the bones, it is a transition zone between woven and lamellar bone, and is a common site of injury after musculo-skeletal trauma in children[10]. Ligaments and tendons are usually stronger than growing bones; in response to the same amount of injury force a child is more likely to fracture, and an adult is more likely to tear a ligament, muscle or tendon. A child's periosteum is a thicker, stronger and more biologically active than that of an adult and often remains intact following a fracture. The periosteum provides some tissue continuity across the fracture site that stabilizes the fracture and promotes more rapid healing[13].

Distal radial fractures are rarely isolated, so a check should be made on isolated ulnar styloid or distal ulna metaphyseal fracture[13]. In completely displaced distal radial fracture the periosteum is torn and elevated. In cases of reversed fracture obliquity, it becomes difficult to reduce the bone end to end with longitudinal traction, as the periosteum tightens around the button –holed proximal end. However the elevated periosteum does provide a framework for rapid cortical remodelling as bone callus form along the elevated margin. The fact that it button holes the distal end hence difficult in alignment and also risk of redisplacement is consistent with the finding that translation of greater than 50% has 60% chances of redisplacement, this is due to the fact that there is torn or ruptured periosteal hinge with a resultant lack of restraint which probably allows for rotational deformity to occur[15].

CLASSIFICATION

Specific classification schemes have not been developed for paediatric fractures[1], but fractures are generally categorized according to:

- Location
- Amount of cortical disruption
- Displacement
- Angulation
- Translation

Greenstick fractures are incomplete fractures with an intact cortex and periosteum on the compressive side. They are usually the results of excessive rotational force. Complete fractures of distal third of radius also occur. Proper treatments depend on differentiating torus and greenstick fractures. This is because torus fracture by the mechanism of injury is inherently stable, hence does not require reduction as do greenstick and complete fractures.

PATIENT ASSESSMENT AND RADIOGRAPHIC EVALUATION

History and clinical examination of the deformity are usually enough to diagnose distal forearm fracture but radiographs are mandatory to assess and classify the fracture and to plan the treatment of the same. Thorough inspection and palpation are required to clinically exclude other injuries .The nerve and vascular examination need to be carried to then exclude these injuries .The wrist and elbow should be examined for swelling, tenderness and unusual prominence that may signify Galeazzi or supracondylar fractures[1].

The radiographic evaluation should consist of anteroposterior and lateral views. Elbow and wrist should be included to rule out other injuries. Radiographs are examined to determine the location; whether metaphyseal or distal diaphyseal, pattern of fracture; torus, greenstick or complete, angulation, displacement of distal fragment and translation. Displacement, translation and angulation are fairly easy to document on anteroposterior and lateral views and they have to be quantified and recorded. Measurements from the radiographs are taken of the inclination of the distal epiphyseal plate in relation to the inner border of the cortex of the distal third of the radial diaphysis in the lateral view for the angulation. The magnitude of the deformity is at least as great as or greater than seen in each view.

On follow up the patients are assessed both clinically and radiographycally for maintenance of the alignment, healing and complications like nerve injury or vascular complication at week two, beyond that one may look for redisplacement at week four for the remanipulated after which one would talk of malunion or proper union.

ANAESTHESIA AT REDUCTION

In our centre these fractures are treated in the outpatient site by the plaster technicians. They some time give sedation or painkillers and at time no sedation or painkillers as there are no guidelines concerning this. In many centres in the US and UK, a large proportion of forearm and distal radius fractures are treated outside the surgical suite, require the treating surgeons to consider and administer appropriate anaesthesia. In the United States, strict guidelines for conscious sedation have been established by the American Academy of Paediatric [16], though a survey in 1993 showed only a third comply[17].

The chosen anaesthetic should be relatively safe and painless at all steps, including fracture reduction. Post reduction amnesia is also desirable. Quick and complete relaxation of the patient and the forearm muscle greatly facilitate reduction. As no one method completely meets these criteria, several different choices exist, each with its own advantages and disadvantages.

Options that exist include quick reduction without anaesthesia, haematoma or intravenous regional block[18] axillary Bier's block[19] intravenous sedation, nitrous oxide (50:50 nitrous oxide and oxygen[20]and general anaesthesia.

General anaesthesia allows the surgeon to concentrate on reduction and stabilization an unencumbered by the proximity of anxious parents. It provides total relaxation with minimal constraints and can easily convert to operative stabilization. Generally not preferred due to requirements of going to theatre, but would be the best.

ADEQUACY OF REDUCTION AND RESULT OF CLOSED TREATMENT

Anatomic reduction is usually not required for paediatric forearm fractures due to potential for growth and remodelling [21]. However the surgeon must be able to define reasonable residual malalignment by answering several important questions

1. What are the acceptable limits of displacement at healing and to what degree do the deformities remodel over time?
2. How is remodelling potential affected by variables such as age and location of the fracture?

Many studies have documented better radiographic remodelling of distal fractures, and fractures in patients less than 9 or 10 years of age[7, 8,12,22,23]. It is important to realize that fractures location and age may not be independent variables. Creasman[22] documented better results in distal fractures however these patients were an average of 3 years younger than patients with proximal fractures. We also know that the distal end is the growing end hence it is bound to remodel more than proximal.

Whether anatomical alignment co-relates with final range of motion is controversial. Fuller and Mccullough[12] demonstrated a positive relationship with residual angulation and eventual range of motion. However, there are certainly examples of excessive malunion with good motion[8]. Conversely, cases of "anatomic" healing with documented motion loss have been reported [8,23] Carey et al[24] reported the follow up data on 33 patients with both bone forearm fractures and demonstrated average angulation of 12 degrees in patients aged 6to 10 years and 10 degrees in patient ages 11 to 15 years. While almost all patients in the former group had full motion, those in the latter group had a small loss of rotation averaging 20 to 30 degrees. This disparity suggests that factors other than alignment may affect range of motion. Perhaps motion loss in such cases is due to contracture of interosseus membrane from the injury and / or immobilization. Published discrepancies between residual angular deformity and final forearm rotation may be due to inability to accurately document and record radiographic malrotation[8, 23,25].

Although differing definitions of acceptable alignment have been delineated in the literature, many patients with residual deformity have good functional results[21]. Some recommendations, which are based on previous studies of malunion in children with relatively good function[8, 12], are that in fractures in children less than 9 years of age with fracture in the metaphysis, one should accept complete displacement of the distal fragment and 30 -40 degrees of angulation. In children more than 9 years one should accept bayonet apposition of up to 1 cm only up to 12 years, but only 20 degrees of angulation in the saggital plane and 15 degrees of angulation in coronal plane, if 5 years of growth is still remaining. As one gets older the luxury reduces and one may require near anatomical reduction to avoid malunion[12]. Children nearing skeletal maturity need more precise reduction.

The normal process of bone remodelling in a child may correct malalignment, making near- anatomic reductions less important in children than in adults. Remodelling can be expected if the patient has 2 or more years of bone growth remaining. Rotational deformity remodels poorly if at all, and should be corrected by reduction. Mild angular deformities often correct themselves, however, as the bone grows, the deformity is most likely to correct it self, if the child is younger, the fracture is closer to the physis, and the angulation is in the same plane of motion as in the nearest joint. Because the amount of remodelling is not predictable, displaced fractures should still be reduced to maximize the chances of achieving acceptable alignment[13].

Fractures in children may stimulate longitudinal growth of the bone, which may make the bone longer than it would have been had if not been injured. This has not been noted in distal radius but more in femur and tibia[13]. In such cases it could be desirable to have some degree of overlap. In distal radial fractures, the overlap depends on the amount of the time left for bone growth; it is 1cm up to the age of twelve[26].

Children do not tolerate prolonged immobilization as adults do. Disabling stiffness or loss of range of motion is distinctly usual after paediatric fractures. After cast immobilization, physical therapy is rarely needed because children tend to resume their normal activities gradually without much supervision. Even though fractures of growing bones generally heal with a large callus, this new bone is still fibrous and not yet restored to its original strength. Because of this the child should avoid collision or contact activities for 2 or 4 weeks, depending on activity level and age, after discontinuing immobilization.

REDUCTION AND CASTING

Historically, incomplete fractures were treated by completing the fractures and then manipulating the bone into an acceptable position and applying a cast [7, 27]. This approach has the critical advantage of increasing the size of the fracture callus and decreasing the risk of refracture. Currently, it is recognized that residual angulation is a result of malrotation and that the fracture should be reduced by rotating in the direction opposite to the deforming force. Traction and manipulation in the apex while rotating will always assist in the reduction.

Most greenstick fractures are supination injuries with apex –volar angulation, which can be reduced with varying degree of pronation. It can be difficult to remember whether to pronate or supinate the hand. Rotating the palm towards the deformity can reduce most fractures. Fractures with apex volar angulation are a result of axial load in supination; therefore, the palm should be rotated volarly (pronation). Fractures with apex dorsal angulation are a result of pronation force; therefore, the palm should be rotated dorsally (supination).

After reduction, the forearm should be immobilized in the same position that reduces the fracture. Studies have documented 10% to 16% rates of redisplacement when greenstick fractures were not adequately rotated in the cast[16, 28]

Distal radial metaphyseal fractures are reduced with a combination of traction, angulation, and rotation of the palm in the direction of angulation. In the case of completely displaced and bayoneted fractures, sustained longitudinal traction is used with finger traps. After the fracture has been brought out to length, deformity exaggeration and rotation may produce end- to-end contact. It may be difficult to obtain apposition, as torn periosteum tightens around the button holed proximal fragment[29]. In these cases, it is acceptable to leave the fragments overlapped as long as rotation and angulation are reduced[29].

Typically these fractures are immobilized in casts. Sugar-long splinting is another form of immobilization commonly used immediately after reduction. If this method is selected, it is important to tighten the splint or convert in to a cast when the initial swelling resolves in 2 to 3 days, high rate of reangulation in distal radius fractures have been reported[29]. Distal radius fractures without ulnar fracture are immobilized in a lesser degree of pronation or supination depending on the apex direction. As these fractures are the result of an angulation force as well as rotation, the position of the wrist is less critical. There are some suggestions that distal radius fractures are more stable in supination because of the action of the branchioradialis.

All fractures are eventually placed in either fibreglass or plaster long arm cast with elbow at 96 degrees. Plaster may be easier to mould, but fibreglass permits better radiographic visualization. Casts are moulded with interior and posterior pressure applied over interosseous membrane. This tends to separate the bones and increase stability in the cast, and a straight ulnar border is produced.

Meticulous casting is critical, as several studies have documented reangulation in 7 % to 14 % of cases[25, 28,30]. Some have blamed poor casting technique[25, 28] Forearm anteroposterior and lateral radiographs are taken after reduction and immobilization, and improvements of residual angulation can then be corrected by wedging the cast[7]. After adequate reduction and mobilization, patient typically return for a follow up radiographs 1 to 2 weeks after injury. Several studies have documented reangulation during the first 2 weeks[7, 25].

OPERATIVE INDICATIONS AND TECHNIQUES

Traditionally, fractures of the distal radius in children have been treated by closed reduction and immobilization in a plaster cast. Maintenance of satisfactory alignment can be difficult, however, and redisplacement and malunion have been widely described[3, 25, 31, 32]. Haddad and Williams[33] in their study reported that 21% of fracture of distal radius redisplaced early after reduction, though in their study they included both forearm bone fractures. The acceptable degree of residual deformity remains ill defined. Even if such fractures heal in a malunited position, they remodel with little or no functional deficit[4], and up to 20^0 of residual dorsal angulation may be accepted with the expectation of satisfactory remodelling. Nevertheless, poor functional outcome after such fractures has been associated with both residual angulation and translation[33]. Choi et al [34]confirmed that translation of the radial fractures had an unfavourable outcome. Roberts [31] found that, in fractures of the distal third of radius, loss of rotation was related to residual deviation of the radius, but not dorsal angulation. Even temporary restriction of the movement or abnormal appearance may not be acceptable to the child or parents.

Loss of position in the cast has been shown to be the most important factor affecting the position at union[32]. The use of properly fitting casts using three –point fixation has also been emphasized[25, 33]. Haddad and Williams[33] felt that the outcome was related to the experience of operator. Proctor, Moore and Paterson[35], found that complete displacement of the fracture and failure to achieve a perfect reduction were both associated with significant increase in the incidence of redisplacement.

The use of percutaneous Kirschner wire fixation has been recommended, but indications vary. Proctor et al[35] advocated fixation in all cases in which a perfect reduction could not be achieved, whereas Mclauchlan et al[36] recommended wires for instability or irreducibility. Gibbons et al[21] proposed that fractures of the distal radius in the presence of intact ulnar should be wired, Mclauchlan et al[36] proposed that the wires be used to augment reduction in children who have a completely displaced metaphyseal fracture of the distal radius in a clinical trial having concluded that completely displaced fractures of the distal radius have a high propensity for redisplacement despite satisfactory initial reduction. Because most paediatric radius fractures are treated by closed reduction with good results, operative reduction and immobilization are rarely necessary.

The indications for surgical intervention in these fractures include

1. Open fractures; which this study will exclude
2. Irreducible fractures, with or without soft tissue interposition
3. Unstable fractures after reduction

Several different techniques are available including;

a. Pin and plaster[34]

b. Open reduction and interval fixation with plate

c. External fixation (non-bridging (bridging).

Percutaneous pinning with Kirschner –wire for unstable but reducible distal radius fractures has been described in studies; most authors report excellent results in these severe cases.

Anthony and Ruskin[37] described the use of bridging and non-bridging external factors in displaced, extra-articular distal radius fractures. Nielsen and Simonsen describe plating in displaced fractures in children[38]

COMPLICATIONS

Soft Tissue

Skin complications

These are due to incorrect timing of the cast application or incorrect placement of *a cast. Due to swelling, the constricting bandage or a circular cast will* cause pressure necrosis and at times leads to compartment syndrome. Fibreglass can have higher chances of causing this complication. Plaster of Paris, which generates less pressure and accommodates more swelling, is recommended. When complication occur, it need to be split

Nerve injuries

Early reports of fractures of the distal radius have indicated that neurological injuries were infrequent, but later it was demonstrated to exist[39]. Nerve injuries most frequently involve median nerve. These are usually secondary injuries due to partial reduction and malunion or instability causing carpal tunnel syndrome, rarely does nerve injury occur as primary complication due to entrapment or direct contusion. Ulnar nerve is less commonly injured. When due to carpal tunnel syndrome, one needs to relieve pressure and wait for recovery of the nerve.

Vascular complications

These are extremely rare. Entrapment has been reported as a reason why at times fractures cannot reduce[40]. Treatment may be complicated.

Compartment syndrome

Can occur due repeat manipulation and circumferential casts. Fasciotomy will be required to relieve the pressure.

Bony Tissues

Malunion

Distal radius fractures treated conservatively will rarely present with malunion that precludes activities of daily living. In the rare cases in which motion loss is greater than 60 degrees, surgical correction can be obtained with drill osteoclasis and casting[41] or with open osteotomy and plating[42]. Both techniques will increase motion; however better results are obtained when surgical correction is performed within one year of the original fracture[42].

Occasionally, cosmetic concern will predominate over functional limitations. Osteotomy may be performed to improve appearance but patients should be warned of potential motion loss[42].

Refracture

Though uncommon, refracture can occur as long as 6 months after the original injury[43]. Some have documented less optimal clinical outcome in cases of refracture[23, 44]; in such instances, operative intervention may be indicated to ensure an adequate reduction. Increased rates of refracture have also been documented after immobilization of greenstick fracture, possibly because of weaker union at the fracture cortex due to inadequate callus formation.

Redisplacement

Redisplacement of these fractures as seen above is about 7-14% in other literature[3] and more in some. This is explained more elsewhere in this manuscript.

JUSTIFICATION OF THE STUDY

Distal radius fractures are the most common fractures seen in children both locally and globally[1, 2, 3]. The conservative management of the fracture with plaster of Paris or as in United Kingdom cast would be enough for most fracture of the distal radius in children. But there has been reported in literature of redisplacement of these fractures[7] and that, these may eventually require operative management.

Problem: There are no studies that have been carried out in Kenya to asses the magnitude and the risk of redisplacement of the isolated radius fracture in children and adolescents aged 6-15 years. This study sought to establish mainly the incidence and the risk of redisplacement of the isolated radius fractures in children and adolescents aged 6-15 years in Kenyatta National Hospital.

OBJECTIVES

- To evaluate the incidence of redisplacement/ reangulation of isolated closed distal radius fractures in children and adolescents aged 6-15 years at Kenyatta National Hospital (KNH)

SPECIFIC OBJECTIVES

1. To describe the type of isolated distal radius fracture in children and adolescents aged 6-15 years at Kenyatta National Hospital (KNH)
2. To describe the common management given to children and adolescents aged 6-15years at Kenyatta National.
3. To evaluate the risks of redisplacement of the isolated distal radial fractures in children and adolescent aged 6-15 in our referral hospital
4. To determine the incidence of redisplacement/reangulation of the isolated distal radius fracture in children and adolescents aged 6-15 years at Kenyatta National Hospital.

MATERIALS AND METHODS

STUDY DESIGN

This was a prospective hospital based descriptive cross sectional study that was carried out between 22nd of June 2005 and Feb. 28 2006.

STUDY POPULATION

One hundred consecutive patients who were children and adolescents of age 6-15 years with isolated fractures of the distal radius seen at Kenyatta National Hospital casualty and followed up in the fracture clinic with the above fracture were recruited after consenting, using the consecutive sampling method.

SAMPLE SIZE

From previous studies elsewhere the proportion of isolated fracture of distal radius redisplacement has been ranging between 2% up to 14% in this study 7% used as an average value.

Give a confidence interval 0f 95%, a level of precision of 5% and a confidence interval 5%, the minimum sample size for the study is obtained using the following formula

$$N=\frac{Z^2 \{(P (I-P)\}}{D^2}$$

Where N= sample size

P= expected proportion of redisplacement 7%

Z= standard deviation of the 95th percentile (1.96)

D= level of precision (5%)

$$N = \frac{(1.96)^2 (0.07 (1-0.07))}{(0.05)^2}$$

=100.03528
= 100

STUDY SITE

The patients were seen in casualty, and were also followed up in the fracture clinic in Kenyatta National Hospital.

METHODOLOGY

Children and adolescents aged 6-15 years with isolated fracture of the distal radius whose parents/guardians gave informed consent and met inclusion criteria were consecutively sampled. The children were recruited into the study from casualty and fracture clinic, those who were not seen in casualty were recruited the following day, if it falls on a weekend then the following Monday. The reductions and casting were done by the plaster technicians who are the personnel who normally do the reductions. Check x-rays were immediately asked for in casualty and the patient who do not have means to do immediately were asked to do the following day when they return for follow up to check whether the cast is tight or any immediate complication in the fracture clinic. The information gathered from the patients were age, sex, whether the fracture was related to recreation or not, the occupation of the parent, and if there was any significant medical history. *The radiographs* were analysed for fracture location, amount of cortical disruption, angulation, the degree and direction of angulation, displacement and the direction of displacement, as well as translation and degree of translation. From the radiographs the forces that were acting on the limb at the time of fracture were determined and recorded.

The other data collected included record also included type of plaster applied, whether the patients were given any analgesia/sedation or not at the time of reduction.

Radiographs were taken to confirm proper reduction and 20^0 dorsal angulations or less was accepted, if it was more it was redone.

The patient were then followed up in the fracture clinic where at week two and week four check x-ray at each point, for those who had reangulation at week two remanipulation was done under sedation. In the fourth week, if there was redisplacement as show by check x ray , patient were admitted to go for refracture under general anaesthesia with percutaneous pinning. The ones who showed no redisplacement at week two and week four were also noted to have healed in acceptable position and plaster of Paris was removed at week four for those with adequate callus, others who did not have adequate callus were left for follow up with the doctors from the orthopaedic units who run the fracture clinic normally. This data was entered into a questionnaire (appendix I) which was fed into SPSS version 12.0.

CASE SELECTION

INCLUSION CRITERIA

1. All children and adolescents aged 6-15years with isolated fractures of distal radius seen and managed in causality and followed-up in fracture clinic at Kenyatta National Hospital
2. Those who have given informed consent.

EXCLUSION CRITERIA

- Those patients declining consent
- Those patients with intraarticular fractures
- Those patients with fracture dislocation
- Those patients with open fracture
- Those patients with physeal fractures

SAMPLING PROCEDURE

Consecutive sampling of patients meeting the inclusion criteria

ETHICAL CONSIDERATION

1. Only those patients meeting the inclusion criteria who gave informed consent participated in the study.
2. The investigations that were carried out were those routinely performed on *patients seen and followed* up for fracture in Kenyatta National Hospital and posed no extra risk/cost to the study participants
3. All information obtained in the course of the study remained confidential.
4. Any complications noted were communicated to the primary care provider of the patients to facilitate management.
5. Approval for the study was obtained from the Kenyatta National Hospital Research and Ethics Committee

LIMITATIONS

- Patients aged 6-15 years with isolated distal fracture of the radius seen and followed up in Kenyatta National Hospital represented data from a single site.
- Given these was outpatient on follow up there were losses of patients to follow up.

DATA COLLECTION

- Socio-Demographic and initial clinical data of patients was obtained by the investigator using a prepared questionnaire (appendix I).
- The follow up clinical data of patients was also obtained from patients and/or files using prepared questionnaire (part of Appendix I)
- Some radiographic data for follow up was extracted from the patients files by the investigator

DATA ANALYSIS.

The results were analyzed by SPSS 12.0 version. Odds ratio, Pearson's Chi-square test and Fischer's exact test was used to determine associations between categorical variables as appropriate. Differences was considered significant at $P<0.05$

RESULTS

One hundred children were recruited into the study; one child had bilateral distal radial fractures which made it one hundred and one fractures in the initial stage. Sixty four were males, fifty seven were children under the age of ten (Table 1) and thirty-four had sustained fractures as a result of involvement in games.

Table 1. Distribution by age and gender

	number	%
Age categories		
6-10	57	57
11-15	43	43
Gender		
Male	64	64
Female	36	36

The occupation of the father and the mother were grouped , the mother who were housewives, casual labourers or business of vending were grouped as low socioeconomic class and those who were teachers, accountants and business women who were doing the shop keeping or wholesale business were grouped to be middle class. This also applied to the fathers. Forty five parents were of low socioeconomic class and fifty five of the parents were middle socioeconomic class.

Table2. Distribution by characteristics of the fracture at the time first seen

	Number	%
Location		
Metaphysis	92	91.1
Diaphysis	9	8.9
Cortical disruption		
Torus	32	31.7
Greenstick	4	4
Complete	65	64.4
Angulation direction		
Dorsal	58	57.4
Volar	1	1
Non angulated	42	41.6
Displacement		
Dorsal	56	55.4
Volar	1	1
Bayonet	2	2
Non displaced	42	41.6
Translation		
None	51	50.4
<50%	35	34.7
>50%	15	14.9

Ninety two fractures involved the metaphysis and only nine were in the distal third of the radial diaphysis (Table 2), Sixty five were complete fractures, and with thirty two being torus and only four were greenstick fractures (Table 2). Fifty nine of the fractures were angulated (with fifty six of the angulations on the dorsal direction but with apex facing the volar aspect and only one was volar with apex facing dorsal direction) and forty two were non-angulated.

Fifty six of the fractures were dorsally displaced, one was volarly displaced, there were two bayonet appositions and forty two were non-displaced fractures (Table2). Fifty one of the fractures were none translated with thirty five of the remaining being less than 50% translation and fifteen having greater than 50% translation (Table 2). Fifty four of the fractures were judged (from the radiographs)to be as a result of bending forces, fifteen as a result of shear forces and thirty two as a result of compression forces.

Sixty fractures required reduction, forty one did not require reduction (thirty two of them were torus, one was greenstick none angulated and eight were complete none displaced) but required simply application of plaster of Paris to immobilise them. Pethidine 1mg/kg was administered to nine patients; ten were administered to valium at 0.1mg/kg while three were administered to both valium and pethidine at the above doses at reduction; while seventy eight had quick reduction under no analgesia.

Ninety nine of the patients got below elbow cast while only one had above elbow. Thirty six fractures had satisfactory reduction; fourteen fractures had unsatisfactory reduction and were redone immediately and there was no immediate check radiographs for the other ten fractures so it was difficult to decide at the time of reduction to decide whether they were unsatisfactorily reduced or not at the casualty at the time they were seen, but the check radiographs were done within three days and eight were satisfactorily reduced while two were not making satisfactory to be 44 and unsatisfactory to be 16.

At week two, seven patient failed to turn up while two had no check radiograph, so only ninety two fractures were evaluated for evidence of healing or redisplacement and among the ninety two thirteen were found to have redisplaced , these nine patients were taken to have been lost to follow up at week two. The thirteen fractures were remanipulated under sedation with valium at 0.1mg/kg, they were asked to come with check radiographs in two weeks.

In the fourth week, five patients failed to turn up and four did not have check radiographs, so only eighty two fractures were evaluated for evidence of healing or redisplacement. There were fifteen redisplaced fractures, four of the ones that were satisfactory at week two and eleven of the ones who had initially redisplaced at week two. Two patients who were remanipulated at week two were found to be satisfactory at the follow up at week four. The fifteen patients were admitted for operative reduction under anaesthesia, since this study's end point was to be four weeks of follow up and the main aim of study was to find out the rate of redisplacement after casting, these patient were not followed up in the wards and afterwards.

The immediate complication noted was tight casts in ten patients on follow up in fracture clinic the following day which casts were removed and recasting done.

The incidence of redisplacement to be 14.2% at week two and 17 % at week four in consideration of the whole population under study but if one would consider on the fracture which are really at risk of redisplacement fracture, that is complete and greenstick it would be 20.3% at week two and 21.9% at week four. This is certainly significant

Table 3. Effect of age and gender on redisplacement at week two

	Redisplacement at week two Yes	No	P value
Age categorized			
6-10	6	46	0.387
11-15	7	32	
Gender			
Male	10	49	0.324(Exact test)
Female	3	29	

In analysis of the above data it was found that at week two six out the fifty two of the under 10 and seven of the thirty nine of the 11 to 15 redisplaced, at week four eight of the forty six under ten and seven of the thirty five 11 to15 redisplaced. Using the Pearson Chi-square of one sided significance gives p value of 0.387 at week two and 0.587 at week four (Table 3 and Table 4).

At week two ten of the fifty nine male and three of the thirty two females redisplaced, at week four eleven of the fifty one males and four of the thirty females redisplaced(Table 3 and Table 4) . Using Fisher's exact test it yielded p value 0f 0.324 at week two and p value of 0.284 at week four.

Table 4. Effect of age and gender on redisplacement at week four

	Redisplacement at week four		P value
	Yes	No	
Age categorized			
6-10	8	38	0.587
11-15	7	29	
Gender			
Male	11	40	0.284(Exact test)
Female	4	27	

The second week for the games found seven of the fifty nine of those whose fracture were not as a result of game involvement redisplaced, six of thirty two seen then who were involved in games at the time of fracture redisplaced. At week four nine of fifty one children whose fractures were not as a result of games involvement redisplaced and six of those who were involved at the time of the fracture redisplaced(Table5 and Table 6), yielded a p value of 0.370 at week two and p value of 0.978 at week four with Pearson Chi square test.

Table 5 and Table 6 also shows that in terms of the Parents' socioeconomic status, five of the forty one of the low class and eight of the fifty middle class at week two redisplaced this yielded a p value of 0.606 using the Pearson's Chi square test. Eight of the thirty five of low class and seven of the forty seven middle class redisplaced at week four, yielding p value 0.333 at week of four

Table 5. Effect of parents' socioeconomic status and games related fracture on redisplacement at week two

	Redisplacement at week two		P value
	Yes	No	
Parents' socioeconomic status			
Low	5	36	0.606
Middle	8	42	
Games related fracture			
Yes	6	26	0.370
No	7	52	

For the location of the fracture, thirteen of the eighty four metaphyseal fractures redisplaced and none of the eight diaphyseal fractures redisplaced at week two This yielded p value of 0.237with Fisher's exact test of one sided significance(Table 7) . At week four fifteen of the seventy six metaphyseal fractures and none of the seven diaphyseal fractures redisplaced at week four, it yielded a p value of 0.341 with Fisher's exact test of one sided significance showing they are not statistically significant(Table 8).

Table 6. Effect of Parents' socioeconomic status and games related fracture on redisplacement at week four.

	Redisplacement at week four		P value
	Yes	No	
Parents' socioeconomic status			
Low	8	27	0.333
Middle	7	40	
Games related fracture			
Yes	6	25	0.978
No	9	42	

In regard to the completeness of the fracture, none of the thirty three non complete (which are torus and greenstick) fractures redisplaced and thirteen of the complete fractures redisplaced at week two and none of the twenty seven non complete fractures redisplaced and fifteen of the complete fracture redisplaced at week four (Table 7 and Table 8).It was found to be significant, giving p value of 0.003 and 0.001 at week two and week four with the Fisher's exact test respectively.

Table 7. Effect of Location of fracture, amount of cortical disruption and displacement on redisplacement at week two.

	Redisplacement at week two		P value
	Yes	No	
Location of the fracture			
Metaphyseal	13	71	0.237(Exact test)
Diaphyseal	0	8	
Amount of cortical disruption			
Complete	13	46	0.003(Exact test)
Others	0	33	
Displacement			
Displaced	12	42	0.006(Exact test)
Non displaced	1	37	

Influence of displacement on redisplacement

In terms of displacement, at week two twelve of the fifty four displaced isolated distal radius fractures redisplaced and one of the thirty eight non displaced fractures redisplaced and at week four. Fourteen of the fifty one displaced fractures redisplaced and one of the thirty two non displaced redisplaced, yielding p value of 0.006 and 0.004 with Fisher's exact test at week two and four respectively (Table 7 & 8).

Table 8. Effect of Location of fracture, amount of cortical disruption and displacement on redisplacement at week four.

	Redisplacement at week four		P value
	Yes	No	
Location of the fracture			
Metaphyseal	15	61	0.341(Exact test)
Diaphyseal	0	7	
Amount of cortical disruption			
Complete	15	41	0.001(Exact test)
Others	0	27	
Displacement			
Displaced	14	37	0.004(Exact test)
Non displaced	1	31	

Influence of Angulations on redisplacement.

In terms of angulation of the distal fragment of the isolated distal radius fractures seen in this study, twelve of the fifty three angulated fractures redisplaced and one of the thirty nine fractures which were not angulated redisplaced at week two and fourteen of the fifty angulated fractures redisplaced and one of the thirty three non angulated redisplaced at week four yielding p of 0.005 and 0.003 at week two and week four respectively with Fisher's exact test. The Odds ratio calculation was 11.68 at week two and 14.53 at week four (Table 9 and Table 10).

Influence of degree of angulations on redisplacement

In consideration of the degrees of angulations (Table 9 and Table 10) it was noted that at week two one of the twenty one 10^0 to 20^0 and eleven of thirty two 20^0 to 50^0 of dorsal angulation redisplaced and at week four two of the eighteen 10^0 to 20^0 and twelve of the thirty two 20^0 to 50^0 redisplaced giving a p value of 0.011 and 0.044 with Fisher's exact test of one sided significance respectively for week two and week four showing they are statistically significant..

Table 9. Effect of angulations, severity of angulation, translation and severity of translation on redisplacement at week two.

	Redisplacement at week two		P value
	Yes	No	
Angulation			
Angulated	12	41	0.005(Exact test)
Non angulated	1	38	11.68(odds ratio)
Angulation severity in degrees			
10-20	1	20	0.011(Exact test)
20-50	11	21	
Translation			
Translated	11	36	0.009(Exact test)
Non translated	2	43	
Translation percentage			
Less than 50%	7	30	0.004
Greater than 50%	4	7	0.008(exact test)

Influence of translation on redisplacement

In terms of translation of the fragments on one another, the result of this study show that at week two, two of the forty five non translated fractures and eleven of the forty seven translated fractures redisplaced and at week four two of the thirty nine non translated and thirteen of the forty four translated fractures redisplaced as shown in Table 9 and Table 10, yielding p value of 0.009 and 0.004 with Fisher's exact test at week two and four respectively.

Table 10. Effect of angulations, degree of angulation, translation and percentage of translation on redisplacement at week four.

	Redisplacement at week four		P value
	Yes	No	
Angulation			
Angulated	14	36	0.003(Exact test)
Non angulated	1	32	14.53 (odds ratio)
Angulation degrees			
10-20	2	16	0.044(Exact test)
20-50	12	20	
Translation			
Translated	13	31	0.004(Exact test)
Non translated	2	37	
Translation percentage			
Less than 50%	6	25	0.036
Greater than 50%	7	7	0.043(exact test)

In regard to the severity of translation, those fractures whose translation were less than 50%, seven of the thirty seven redisplaced and four of the eleven of the fractures whose translation by greater than 50% redisplaced at week two and at week four six of the thirty one of the fractures whose translation of less than 50% redisplaced and seven of the fractures whose translation were greater than 50% redisplaced (Table 9 and Table 10). This yielded p value of 0.004 and 0.036 with Fisher's exact test at week two and four respectively and odds ratio of 7.25 and 4.38 for week two and week four respectively.

Table 11. Effect of forces acting on the bone at time of fracture, analgesia and satisfactoriness of reduction on redisplacement at week two.

	Redisplacement at week two		P value
	Yes	No	
Forces acting on bone at fracture time			
Bending	12	37	0.008 (Exact test)
Shear	1	13	
Compression	0	29	
Analgesia given or not given at reduction			
Given	5	16	0.147
Not given	8	62	
Reduction satisfactory or not			0.001(Fisher's exact test)
Satisfactory	6	41	
Unsatisfactory	6	2	

Influence of Mechanism of injury on redisplacement

For the forces acting on the bone at the time of fracture, twelve of the forty nine who had fractures due to bending forces and one of the fourteen whose fractures were due to shear forces and non of the twenty nine of compressive forces redisplaced at week two, at week four fourteen of the forty eight of the bending forces and one of the eleven of shear and none of the twenty four of compressive forces redisplaced giving p value of 0.008 and 0.007 at week two and week four respectively with Fisher's exact test(Table 11&12).

Influence of sedation during reduction on redisplacement

With regard to whether one got sedation or not, at week two of the seventy children who had not received sedation at reduction eight redisplaced and five of the twenty who had received redisplaced, at week four eight of the sixty two of those who had not received sedation and seven of the twenty those who had received analgesia redisplaced giving a p value of 0.147 and 0.024 with Pearson Chi square test at week two and week four respectively (Table 11 &12). The low p value found would be explained by the fact that the numbers were few hence not a justification for not giving analgesia at reduction.

Influence of immobilization on redisplacement

Thirteen of ninety one patients who had below elbow cast redisplaced and the only one child who had above elbow cast did not redisplace, at week four fifteen of the eighty two patient who had below elbow cast redisplaced and the only one patient who had above elbow cast did not redisplace, giving p value of 0.859 and 0.819 with Fisher's exact test at week two and week four respectively.

Table 12. Effect of forces acting on the bone at time of fracture, analgesia and satisfactoriness of reduction on redisplacement at week four.

	Redisplacement at week four		P value
	Yes	No	
Forces acting on bone at time of fracture			
Bending	14	34	0.007 (Exact test)
Shear	1	10	
Compression	0	24	
Analgesia given or not given at reduction			
Given	7	13	0.024
Not given	8	54	
Reduction satisfactory or not in the immediate check x-ray.			0.000(Fisher's exact test)
Satisfactory	7	37	
Unsatisfactory	7	1	

At week two 55 of the 60 that required reduction came for follow up, at week four only 52 of the 60 came. In analyzing the reduction and whether it was satisfactory or not, of the forty seven fractures seen which were satisfactorily reduced as per x ray at the initial reduction, six redisplaced and six of the eight fractures that were not satisfactorily reduced redisplaced, while at week four seven of the forty four fractures that were satisfactorily reduced redisplaced and seven of the eight fractures that were unsatisfactorily reduced redisplaced. This yielded p value of 0.001 and 0.000 at week two and week four respectively with Fisher's exact test (Table 11 &12). The analysis was done at the end of the study hence the inclusion of those who did not have their check x ray immediately but availed the check x rays 3 days as is explained above.

Of the patients who required reduction, twelve of the fifty five fractures redisplaced and one of the thirty seven fractures who did not require reduction (non displaced and non angulated complete) redisplaced at week two and at week four fourteen of the fifty two who required reduction and one of the thirty fractures who did require reduction redisplaced, this gives p value of 0.009 and 0.002 with Fisher's exact test at week two and week four respectively.

Table 13 also gives the summary at the follow up , of the seventy people seen in week two who had satisfactory reduction previously at week two , four had redisplacement at week four and sixty six did not redisplace, eleven of the thirteen fractures who were remanipulated at week two redisplaced. Two which were initially remanipulated were acceptable at the radiograph of week four.

The remanipulated at week two were done under sedation with Valium at 0.1mg/kg and pethidine at 1mg/kg. At week four only in two was reduction seen to have held, and of those who did not redisplace earlier, four were found to have redisplaced. P value calculate for this was <0.001.

Table 13 .Summary on follow up

		Follow up at four weeks; redisplacement in X-ray		
		No	Yes	Total
	Satisfactory at 2 wks	66	4	70
	Remanipulated at 2wks	2	11	13
Total		68	15	83

The patient that were seen initially were one hundred then at week two we saw ninety three patients, as was explained above two did have a check radiographs so they could not be evaluated for redisplacement as if they had radiographs, this also occurred in week four where eighty seven patients were seen but five did not have radiographs for evaluation.

DISCUSSION

Magnitude of Redisplacement

The traditional treatment of closed isolated distal radial fractures has been in most centres, reduction and immobilization in a cast after manipulation of the fracture (for complete or greenstick fractures). In most cases it has been shown to have good functional results [12, 35]. Loss of reduction in the cast is a well documented problem.

Various rates of redisplacement have been sighted in the literature, some as high as 34%[35] and some 7-12%[3], 2%[44] others 25%[6], these studies were inclusive of both forearm bone fractures and did consider only the completely displaced fracture as the beginning point. All of them were retrospective studies. This study considered only the radius fracture, was prospective observational study. Our rates are comparable to the others even though most of these studies were done for fractures of both radial and ulna bones. Most of the literature before it was for those of combination of ulna and radius except that of Gibbon et al[12]. Gibbon emphasized in their study on the management and the point that came out as the need for percutaneous K- wiring in unstable fractures. The population in his study was just 23 of the isolated distal radial fractures of the 175 populations reviewed, and did not consider the rate of redisplacement of the total but did consider the outcome of percutaneous pinning and cast versus cast alone and their redisplacement rates.

In this study if one considers only the complete and greenstick type of fractures then the rate of redisplacement would be 20.3% and if one were to consider all the fractures it would be 14.2%, this consideration is important since it is only this category of fracture types that redisplace. In the David and et al [30] study, only 29 of the 547 files reviewed were only radius complete fracture, 81 were only radius torus and 88 greenstick. Of the greenstick only 8 had recurrent reangulation and only 3 of the 29 complete had reangulation, this gives 11% for greenstick and about 9 % for complete. The other studies by Haddad and William[33] as involving both bone fracture of the forearm and discussed below these factor contributes to the rate of redisplacement[6, 37,45]. In the study by Chan et al[46] they found remanipulation rate of 11.7% of the 1155 children, that is only 136, they found lower rate by senior registrars during day and high by junior registrars during night.

The factors that might have played in the rates seen in this study due to differences in the protocol others have used and the one we used include the fact that in these studies they considered both bone distal forearm fracture with only a few being isolated and in some[6, 35] they recorded the fact that the presence of ipsilateral ulna fracture increases the chances of redisplacement, though some disagreed[21]. It is also noted that there was revision of the fractures that were not satisfactorily reduced immediately and this could have contributed by reducing the number of imperfect reduction that contribute to redisplacement as recorded by Proctor et al[35]. Zamzam and Khoshhal[6] in their study found that deep sedation or hematoma block could result in redisplacement, factors absent in this study, it has also been noted from the study of Bohm et al [45] that both bone fracture contributes to remanipulation significantly p value of 0.001 in their study) as well as above elbow cast, both factors were absent in our study.

But as mentioned above, Haddad and Williams[33] found in their study a high number of redisplacement of about 21%, though they were analyzing even those with ulna involvement in their study. Various literature reports even lower figures, as low as 2%[44] in some and some have 7%[3]. These figures demonstrate the problem as seen after casting with various reasons advanced as to why the fractures do redisplace as recorded above. Gibbon et al recorded the fact that ipsilateral ulna can be a factor in hindering good reduction and hence should be pinned prophylactically [21] while Proctor et al [35] did not demonstrate that, but found out that with intact ulna the fracture was likely to be completely displaced. Zamzam recorded that it is a risk factor in redisplacemnet[6], as did Davis and Green [30].

Despite the capacity to remodel, malunion is still an unfortunate complication in these fractures[43] and are the major concern in cases of redisplacement, which are not attended to. The unsatisfactory results of these fractures have been variously attributed to failure to remodel rotational malalignment by Daruwalla et al[8,] and Creasman et al [22]. Unrecognized loosening of the plaster during treatment by Voto et al[44,] and the presence of radial deviation by Roberts[31] and in a recent study by Bhatia M and Housden PH[47] which is not yet published but appeared in web site of Injury journal also talked of poor plaster application technique to be a factor. The study protocol did not consider these factors hence one can not really comment on these in relation to this study.

The study protocol set and approved by the ethics committee did not require active participation of the investigators in the management of the patients as it was observational , however, the ones that needed admission were advised to be admitted for pining as per the protocol. The follow up rate in this study was satisfactory, with only seven failing to turn up in the second week and four in the second week. In terms of percentage for the ones analyzed it would be 91% and 82% for week two and four respectively. This compares with 82% for McLauchlan et al[36]. .

Remanipulation was done in week two in this study, Voto et al[48]reported to have had the remanipulations in their study safely done upto 24 days post fracture with majority at 1-2 weeks. They found redisplacement rate at 7% in their study and reports that remanipulation was successful, in other studies however [30], it was fond to be not successful, our study found the success rate of remanipulation to be low, 2 out of thirteen, that is 15.38% success. Davis and Green [30] did their remanipulation upto three weeks post injury and only left those that were identified after three weeks; their redisplacement rates were averagely 10%. The remanipulation done in this study were up to two weeks post injury , past which one considered operative reduction and pinning with Kirschner wires under general anaesthesia. In this study, the protocol did not include the outcome of the operative reductions so that every patient who was admitted was assumed to have reached the endpoint of their follow up

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Risk factors for Redisplacement

Sex in relation to redisplacement

The number of patients seen was one hundred. One patient had bilateral fractures and that is why in some instances the n appears to be 101, majority of the fractures seen in this study were affecting boys, that is sixty four boys and thirty six girls giving a ratio of 1.8:1. This compares with ratio in other literature [15] of 2.6:1. This could be due to the fact that boys are more outgoing and are in general more active than the girls. It was also noted that the gender of the patient had no influence in the redisplacement of the fracture. This is in agreement with other findings by Proctor et al [35], who found that gender of an individual in their study did not contribute in the redisplacement of the fracture.

Age in relation to redisplacement.

In terms of age, the majority of the children seen were below ten years of age accounting for 57% of the patients seen, it was noted in this study again as it was noted by Proctor et al [35], that it does not impact on redisplacement.. Age as a factor is important in terms of the remodelling of the fracture, those who are younger, greater latitude is given in terms of the degree of angulation allowed[7, 8,] and those who are older one would want to be as anatomical as possible in the reduction[12]. Generally speaking, the fractures that occur in the younger child and also are more distal with less angulation have better results[12]. It is important therefore that this study does confirm that it is not a factor in contributing to redisplacement, which of course is determinant in the morbidity of this fracture.

Games in relation to redisplacement

The injuries due to recreational activities had been noted to be in the increase[1], and in our set up, this study indicate the level of them being the cause of fracture at 34%, which is significant , however, they were noted not to have any value in predicting the redisplacement of radial fractures, none of the literatures reviewed has ever related the recreational factor to redisplacement though Proctor et al [35] did relate the cause of injury to redisplacement and found that it did not have significance in predicting the redisplacement, this could be due to the fact that these type of injuries are not more severe than the others due to falls other than during playing.

Socioeconomic status of parents and comorbid conditions in relation to redisplacement

The socioeconomic status of the parents is up to middle with none in the high class. This suggests that may be most of the high-class individuals take their injured ones to private hospitals and not a public institution like the site of this study. The socioeconomic status did not have an impact on the rate of redisplacement in this study; Proctor et al also noted this in their study[35].

In regard to the other comorbid conditions, there was only one noted, a child of 9 years who had a mitral valve disease and had valve replacement done in 2004. This was insignificant hence the result were not analyzed since the fracture she had did not redisplace, it was not going to have any significance. In the literature seen, none has looked into the comorbid conditions and their effect on redisplacement.

Location of fracture in relation to redisplacement

The metaphyseal fractures were the most common seen in this study, it would be noted that in terms of anatomy[10] as was indicated above, it is made up mostly of a porous bone and also at the junction of epiphysis and diaphysis hence experiences change in the force acting on the bone, hence could explain why there are more fracture of the metaphysis than the distal third of the diaphysis. There was no significance in terms of redisplacement of the fracture as determined by whether it was in the metaphysis or distal third of diaphysis, in this study; Proctor et al also noted that the position of the fracture did not influence the redisplacement of the fracture and so this study confirms and emphasizes what is in the existing literature.

Amount of cortical disruption in relation to redisplacement

The majority of fractures seen in this study were complete fractures of isolated distal radius, majority being in the metaphysis. Certain intrinsic factors affect the response of developing bone and cartilage to potentially injurious forces: (1) energy absorbing capacity, (2) modulus of elasticity, (3) fatigue strength, and (4) density. Each factor is influenced by the changes in the developing bone over a period of progressive maturation. Increasing diaphyseal (and less so, metaphyseal) cortical width and the development of primary and secondary osteons affect the modulus of elasticity and relative density and thereby cause different fracture pattern e.g. greenstick more in diaphysis and complete more in the metaphysis[10] as is seen in this current study.

The peak of growth of bones is associated with higher porosity with increased incidence of fractures in children, peak velocity though differ in boys (14.3 years) and girls (11.9 years), the porosity is marked at the metaphyseal areas hence they easily break when force is applied to them[10]. It has been noted in earlier studies that the incidence of distal forearm fractures peaks in children during early adolescence around the time of pubertal growth[10]. This observation is based on the above explanation of transient increase in cortical porosity as a result of enhanced bone turnover in response to high calcium demand. This could account for this large number of complete fractures though majority of the population were children under the age of ten years, which may seem to negate the above argument. The completeness of the fracture did have a value in predicting the redisplacement; it was found to be significant as shown above.

The natural history for buckle or non-angulated greenstick fractures is towards full recovery after the traditional treatment by cast and presents no problem. Studies have documented 10% to 16% rates of redisplacement when greenstick fractures were not adequately rotated in the cast[16, 28] which we have not noted in this study for both buckle and greenstick, this could be possibly due to few number of greenstick fractures, or possibly due to perfect reduction of the fractures obtained in this study.

The greenstick and torus fractures has been shown in this study to have a good outcome as been shown in the literature elsewhere [49,] though they were few. This is due to the fact that the force applied in causing the fracture is not great enough to cause severe damage to the bone and usually torus fractures do not need reduction, and the cast can be removed in two weeks.

Torus fracture has been said to be inherently stable due to the fact that it occurs usually at the junction of diaphysis and metaphysis, transitional zone from lamellar to woven bone hence usually is an impacted fracture, is a failure of the cortex on the compression side in contradistinction to greenstick fracture which result from failure of the cortex on the tension side[9]. The treatment advocated for in the literature is immobilization in cast for two weeks the removal with only two radiographs, one to confirm diagnosis the other to confirm healing[9].

Initial Displacement in relation to redisplacement

Initial displacement of the distal fragment in this particular study was a significant predictor to the redisplacement of these fractures. In this study the initial displacement is taken to mean angulation and the severity of angulation, direction of the displacement of the distal fracture fragment and the translation of one fragment in relation to the other.

The distal radius in children also remodels well, this especially so in the younger children and in fracture with less angulation as was alluded to earlier, Friberg[4] recorded an alteration in the growth of the distal epiphyseal plate which tends to redistribute growth hence corrects the abnormal inclination of the fracture; the capacity is greatest here for spontaneous correction.

However there is little agreement as to the acceptable angulation that could be allowed. Some have argued for 30-40^{0} for the younger than ten years whose fracture are in the distal part of the radius and less than 20^{0} for those above ten years up to 15 years after which they advocate for near anatomical reduction[7, 12,24]. In this study 20 degrees was used as the cut off point in regard to both satisfactory reduction and redisplacement, many other studies have regarded it too as cut off point[6, 12,] Due to the fact that they remodel well, the fractures have traditionally been treated by reduction in the completely displaced and immobilization in a cast or just casting in the non-displaced.

The findings in this study is that the fact that a fracture is angulated, which could be dorsal, (which was greatest in this study with 56 and only one being volar) or volar is a predictor in redisplacement of the fracture, it was noted that the angulated fractures have a tendency to redisplace than non-angulated fractures,

It was also noted that the greater the angulation the more it is likely for the fracture to redisplace .It was also noted that the degree of angulation contributed as a predictor or risk factor to redisplacement of the distal radial fracture in the early phase. However at week four it was noted that it did not contribute significantly .The categories here were those between ten and twenty and those higher and it was realized that the higher ones redisplaced more.

Whereas some have advocated for accepting bayonet displacement of up to one centimetre in some children under the age of twelve[1], Choi et al [34] in their study says they do not accept any form of bayonet and in fact recommend that they be opened up and pinned prophylactically as they form the fractures at risk of redisplacement, in their study they had 8% whereas in this study it was 2%. It is not easy therefore to have an impact in this study with that low occurrence.

Proctor et al[35] identified two factors which increase the chance of redisplacement; the presence of initial displacement and failure to achieve a perfect reduction, Zamzam et al[6] also noted that initial displacement plays a role. This may be because in these fractures there is also associated translation with injury to periosteum and surrounding soft tissue. Lack of periosteal hinge may affect the stability and increase the incidence of redisplacement. Severe soft tissue injury also does cause increased swelling initially which may lead to the loosening of the cast at one week hence increasing chances of redisplacement. Translation has been associated highly with redisplacement, and has been toted as the single best indicator for predicting the redisplacement[15.] Mani et al [15] did mention in their study that if the radial fracture s displaced by more than half the diameter of the radius, the risk of failure or redisplacement is 60% and 68% if completely displaced, in this study it was noted that at week two it is 50% if translation is greater than 50% and 14% if the translation is less than 50%. Proctor et al [35] also did mention in their study the importance of translation in predicting the redisplacement.

This study confirms that indeed translation is a predictor of redisplacement when comparing the translated versus none translated. It was also noted that the degree of translation also significantly predicts the redisplacement of these fractures, which one was likely to redisplace if the he or she had greater than 50% translation.

Anaesthesia at reduction in relation to redisplacement

The type of pain relief given in this study was Valium and Pethidine for the remanipulation and Valium alone for the initial manipulation, in this study it was noted that administration of sedation had no significant contribution to redisplacement in the initial stage of manipulation .But it was also noted that those who were given some form of sedation in terms of Valium redisplaced more in week four, though one cannot settle it to the sedation per see given other factors that contributes like the displacement that was initially present at the first time the patients were seen.

In the literature, Zamzam and Khoskhal[6] noted that deep sedation and hematoma block used at reduction contributes to redisplacement. This study did not look in hematoma block and since Valium does not result in to deep sedation as such it could have been a factor in the rate of redisplacement seen in this study. It is also important to mention that patient undergoing reduction needs anaesthesia to be relaxed and to enable the one reducing to do a perfect reduction.

Type of cast applied in relation to redisplacement

The type of cast that was applied in this study was mostly below the elbow cast with only one above elbow cast and hence it was difficult to asses the effect, however, in a current study [45] it was found by Bohm et al[45] that there was no significant different between above the elbow and below the elbow cast as far as reangulation was concerned though it was noted in that study that most remanipulation resulted from above the elbow cast and those who had both radial and ulnar fractures. The type of cast as a factor did not contribute significantly to the rate of redisplacement in this study. The fact that there was only one above elbow cast makes one not be able to have any serious conclusive discussion on its effect on redisplacement from this study.

In terms of plaster application techniques, Bhatia and Housden[47] of Canterbury in a study, which is still in an internet publication a head of print at the time this study was being carried out, in the Journal of Injury found that poor plaster technique is an important risk in redisplacement and did come up with Cast index and Padding index to standardize the way cast should be applied in these fractures. In this study, this was not taken into consideration hence we cannot state its effect in the rate of redisplacement and therefore the remanipulations that we have.

Reduction in relation to redisplacement

In this study, a perfect reduction was achieved in forty four(44) fractures of the sixty(60) fractures which required reduction and the check radiographs were available giving the percentage of perfect reduction in our set up to be seventy three(73). There was significant redisplacement of the ones who were unsatisfactory. This does confirm the studies done elsewhere by Proctor et al[35] and Zamzam and Khoshhal[6], which found that initial imperfect reduction is a risk factor in the redisplacement of the distal radial fractures. This has also been demonstrated in the above figures. Choi et al [34] found in their study that the incidence of redisplacement could be reduced form 73% to 20% with perfect reduction using plaster alone without the pins.

This study also confirms what others have written in the literature [6,12,15,21,25,31,33,34,35,36], that imperfect reduction leads to redisplacement as is seen in the examples of the radiographs shown in figure one to six. Figure one and two are the radiographs of twelve year old before the reduction while figure three and four are the radiographs after reduction showing imperfect reduction or what one would consider non reduction and figure five and six shows radiographs at two weeks showing evidence of redisplacement since it did show the angulation and translation to be significantly above the 20^0 dorsal angulation accepted for this study since it was 45^0 dorsal angulation.

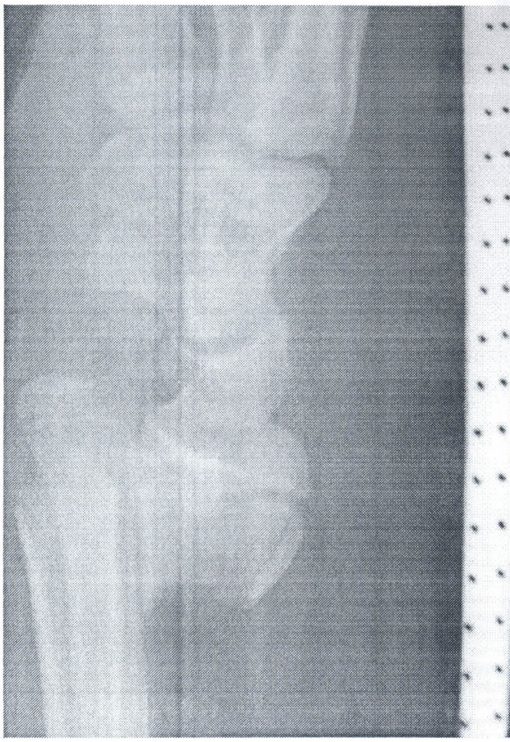

FIGURE 1

Lateral view of

Unreduced fracture in 12 years old

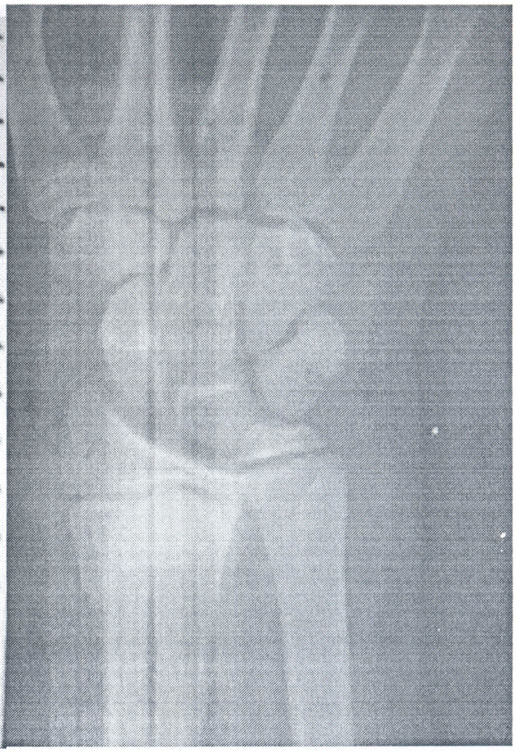

FIGURE 2

Anteroposterior view of the same

It is important therefore to do immediate check radiographs to confirm whether the fractures that are complete and are displaced are properly reduced or not as it could determine the redisplacement of the reduced fracture.

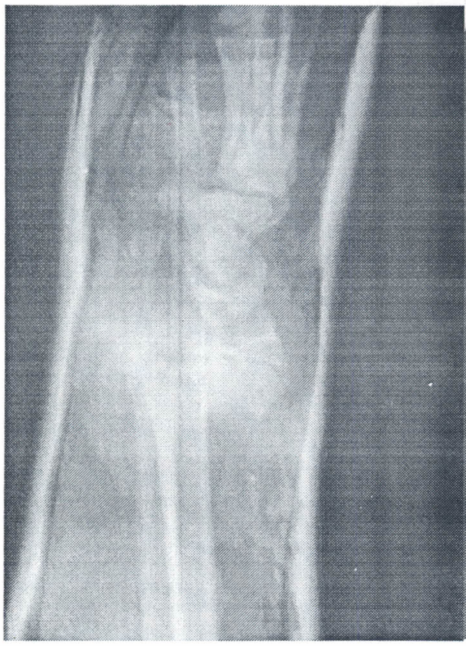

FIGURE 3. Lateral view

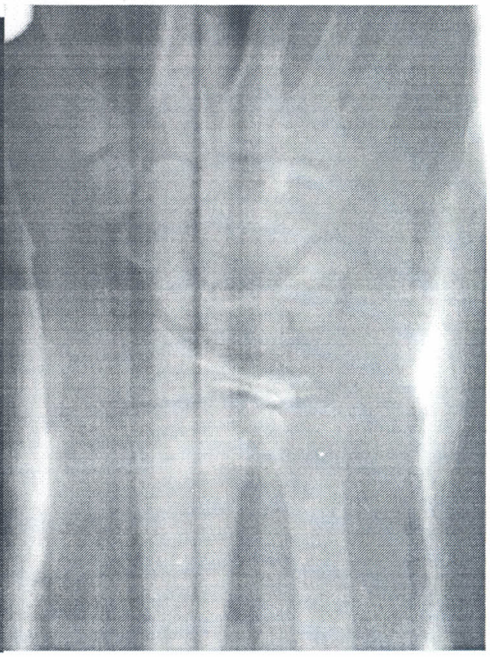

FIGURE 4. Anteroposterior view

Of imperfectly reduced fracture in figure one and two of immediate check x-rays.

Since the reductions were carried out by staff at the same level of experience, it was not easy to compare the experience of staff to the rate of redisplacement. In other literatures[33] it was reported that the experience of the surgeon might be a factor in determining the redisplacement, while Proctor et al[35] did not find any significant relationship between the experience of the person who reduced and the rate of redisplacement.

In other studies it was found that the experience of the personnel at reduction of fracture did contribute to the rate of redisplacement[46] others has argued the fact that the time at reduction did contribute as well as the experience[46]. They found out that the senior registrars during the day had more success with low remanipulation rates (5.3%) than junior registrars during the early

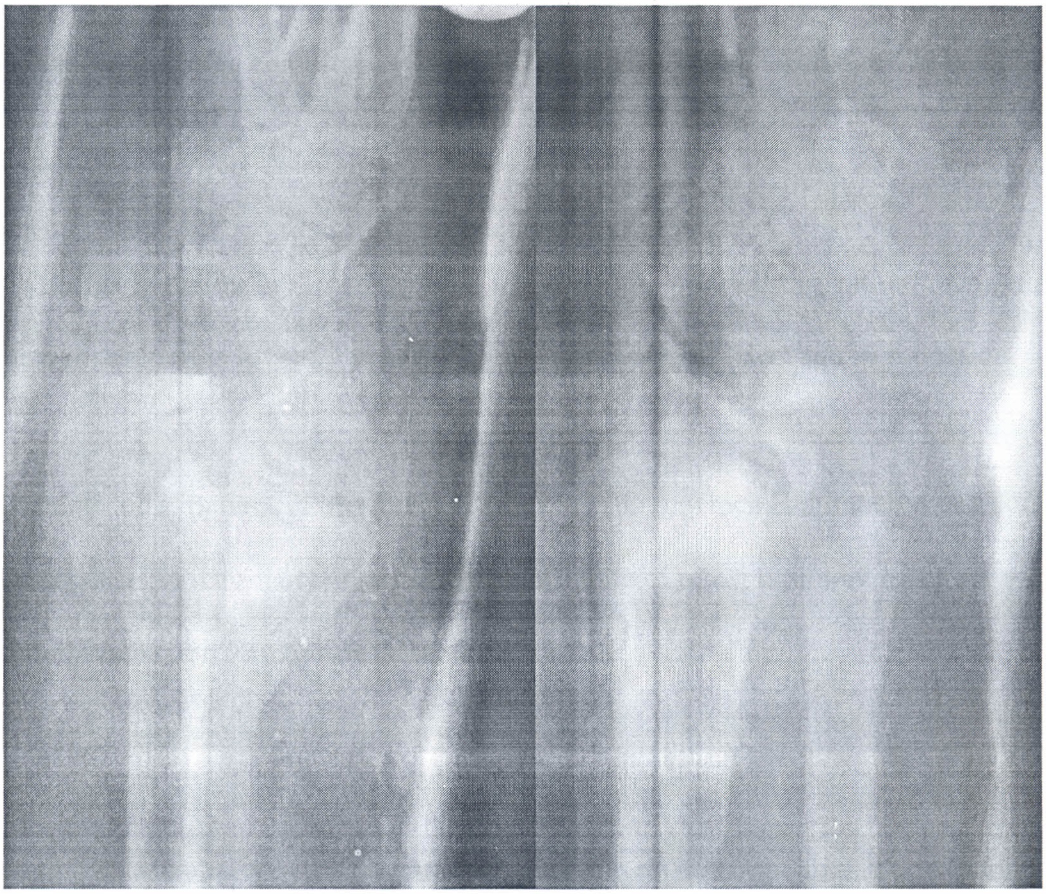

FIGURE 5 Lateral view *FIGURE 6. Anteroposterior view*

Of the figure three and four two weeks later showing redisplacement

hours of the night (23.3%), but they also found out that the junior registrars faired well during the day (7.1%). These factors of experience and the time of reduction in terms of whether it was done at night or not was not factored into this study and hence we can not say how much of influence they had on the redisplacement rate that we have in this study.

CONCLUSION

The pattern of isolated fractures that were seen in this study was mostly metaphyseal in location fractures, complete type, dorsally angulated. Displacement was most often dorsal and half were translated.

The manipulation in this study were under sedation or nothing, rate of manipulation under sedation is low and unacceptable for the patients who require reduction.

Almost all of patient in this study had below elbow, which is hampered any conclusive analysis as to its impact on redisplacement .Rate of redisplacement is high though comparable to international standards.

The factors that put the fractures at risk of redisplacement as found in this study are the initial displacement as defined by; the need of reduction, angulation of the fracture, degree of angulation i.e. the greater the angulation the more likely the fracture is to redisplace, the displacement of the distal fragment, if its displaced the more likely it can redisplaced.

Translation of the fracture, and the degree of translation and imperfect reduction were other factors that significantly predict redisplacement.

Age, sex, socioeconomic status, recreational fracture, location of fracture and type of cast applied were not significant in predicting the redisplacement of these fractures.

The rate of redisplacement in as far as the whole population study is concerned is 14.2% at week two and 15.3% at week four, if one was to consider the complete fracture alone the rate would be 20% and 21.9 % for week two and four respectively, which for the isolated fracture of the distal radius is significant percentage given that the figures in literature are for both radius and ulna bone fractures of the same forearm with the attendant risk as enumerated above

RECOMMENDATIONS

- There is need of immediate check radiographs to determine whether the fracture is perfectly reduced or not in order to act when the fracture is still fresh.

- Emphasis should also be put on the fact that the patient who undergoes reduction should be manipulated under sedation or anaesthesia in order to reduce anxiety and hence be more relaxed for proper reduction.

- The surgeon in charge of casualty should ensure that the plaster technicians manipulate the fractures under anaesthesia and emphasize to them the need of immediate check radiographs.

- This study demonstrates that there is significant rate of redisplacement in the population, as to whether its warrant some extent of prophylactic pinning can not conclusively decided by this single observational study at one centre, this would be bolstered if a long term study on the rate and functionality is undertaken to show similar rates This study alone, given it is in one centre may not be used as the basis of practice in our set up.

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APPENDIX I QUESTIONNAIRE

SECTION I

Socio-Demographic Data

i. Study NO…………………………………

ii. Hospital NO……………………………

iii. Age………………………………………

iv. Sex………………………………………

v. Occupation of the parents (i) Mother……….

(ii) Father……….

vi. Involvement in games Yes/No

If Yes state which games………………

SECTION II

MEDICAL HISTORY

PAST/CURRENT HISTORY OF

1. RECCURENT FRACTURES YES/NO

2. DIABETESMELLITUS YES/NO

3. MALNUTRITION YES/NO

SECTION III

RADIOLOGICAL FEATURES AT FIRST VISIT

1. TYPE OF FRACTURE FROM RADIOGRAPHS

A. LOCATION

METAPHYSEAL…………………………….

DISTAL DIAPHYSIS……………………….....

B. AMOUNT OF CORTICAL DISRUPTION

GREENSTICK…………………………….

TORUS…………………………………….

COMPLETE………………………………….....

C. ANGULATION

a) DORSAL APEX……………DEGREE OF ANGULATION……………....

b) VOLAR APEX………………DEGREE OF ANGULATION…………….

c) NON ANGULATED

D. DISPLACEMENT OF DISTAL FRAGMENT

a) *DORSAL……………………………......*

b) VOLAR…………………………

c) OVERLAP (BAYONET)………………AMOUNT IN Cms

d) NON DISPLACED

E. TRANSLATION

a) NONE

b) <50%

c) >50%

2. MECHANISM OF INJURY FROM RADIOGRAPH

- *BENDING……………………………………*
- *SHEAR……………………………………*
- *COMPRESSION FORCE……………………*

3. TREATMENT GIVEN

a. ABOVE ELBOW TO METACARPAL CAST/SPLINT……………….

b. *BELOW ELBOW TO METACARPAL CAST/SPLINT………………*

4. ANALGESIA ***GIVEN AT REDUCTION***

None………………..

Sedation………………..

5. Reduction

a) Imperfect

b) Perfect

c) Does not require reduction

d) No check x- ray immediately after reduction

SECTION IV _FOLLOW UP

1) **CHECK X_RAY AT 2WEEKS**

EVIDENCE OF REDISPLACEMENT OR REANGULATION

YES/NO

IF YES a) ***GIVE THE DEGREE OF ANGULATION/ AMOUNT OF DISPLACEMENT***

ANGULATION……………………

DISPLACEMENT…………………..

b) MANAGEMENT GIVEN

CHANGE OF CAST…………………………….

NO CHANGE OF CAST…………………………….

2) **CHECK X-RAY AT 4 WEEKS**

1) Of those with evidence of redisplacement at 2 weeks that were remanipulation

1. *Evidence of redisplacement…………………………….*
2. *No evidence of displacement*……………………………….

If there is evidence; a) ***State the degree of angulation/ amount of displacement.***

Angulation………………

Displacement…………

b) ***State Plan of Management***

Admission for operation……………….

Others (Specify)

2) Of those without evidence of redisplacement

Redisplaced…………………………for operation

No redisplacement

4. **OTHER COMPLICATIONS NOTED YES/NO**

If yes (a) what type: *compartment syndrome*……………

Neural injury……………………………

Malunion…………………………………

Others (specify)……………………….

(b) When it was noted post reduction/injury…..

(c) The management given………………………………………

APPENDIX II

Consent Form For Subject Participating in the Study
Study Number---------------------------------
Hospital Number----------------------------------
Contact of Principal Investigator (Dr. Daniel Kinyuru Ojuka): +254722322246, department of Surgery, University of Nairobi.

Purpose of Study

The purpose of the study is to document the rate/magnitude of re displacement of isolated fracture of distal radius in children and adolescents 6-15 years. Seen and carried at Kenyatta National Hospital on follow up. No such information exists for patients in our country. Your child/child under your care participation in the study will help us generate data to design better management protocols for children with isolated fracture of distal radius.

Voluntary Participation

Participation in the study is on a voluntary basis. You can terminate the participation of your child/child under your care at any time with no consequences whatsoever. Participation in the study does not entail any financial benefits.

Confidentiality

The information given to the researcher will be treated with strict confidentiality. No information by which your Child/ child under your care identity can be known will be revealed or published.

Benefits of participation in the study

Early detection of complications will benefit your child /child under your care in that he/ her doctor will be attended to early.

Risks /Disadvantages of participating in the study

- There is no risk anticipated for those participating in the study
- The tests carried out in the study are those done for all patients undergoing treatment and follow up for isolated fracture of distal radius.

Having understood all the above, ***I***, the ***undersigned*** voluntarily agree to allow my child/child under my care to take part in the study.

Signature……………….or thumbprint……………………

Date…………………..

Person who informed and discussed with the patient…………………