Anatomical Bony Arrangement of the Clubfoot and its Correlation with the Pirani Clinical Scoring System: Radiological, Multicenter Study

December 2016 – October 2017

By
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MBBS, University of Gezira, 2013

A Dissertation
Submitted to the University of Gezira in Partial Fulfilment of the Requirement for the Award Degree of Master in Human Anatomy

Department of Anatomy
Faculty of Medicine
University of Gezira
October 2017
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DEDICATION

This work is dedicated to my dear’s family for their support and encouragement. To my supervisors for their proper guidance and patience. And For everyone help in bringing this work to light.
A special dedication to my father Prof. Hayder E.B. he always shows enthusiasm encouragement while guiding me to exert the best effort I can do.
ACKNOWLEDGEMENTS

Firstly praise be to Allah; the Lord and Creator for his generous bounties. Secondly thanks to all people, who made it possible for me to accomplish this research. Special thanks and gratitude to my supervisors; Dr. Mohamed Abdusalam Nurein, this wise man who offered me expert valuable advices, support and scientific guidance. And Mr. Mustafa Abass for his caring, professional guiding and support.

I’m also grateful to those colleagues who have supplied me with their opinions. In particular I would like to thank Dr. Mohamed Al-Mahdi Ali Saleh director of Gezira traumatology centre for his cooperation and permission to conduct this research free of charge for the patients involved in the study.

At last but not least for the patients involved in this study wishing them a full recovery.
Anatomical Bony Arrangement of the Clubfoot and its Correlation with the Pirani Clinical Scoring System: Radiological, Multicenter Study

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Abstract

Club foot or congenital talipes equinovarus (CTEV) is a common developmental disorder of the foot, affecting 1 per 1000 live births, with male to female ratio 2:1. In about half of those affected, both feet are involved. The Pirani score is a valid, reliable and easy to use method to assess the severity of the condition clinically, although it’s widely used, its prognostic value remain questionable. While the use of radiographic assessment cause much debate regarding its benefit, utilities and parameters, it gives an objective measures to the deformity. So this study aim to evaluate the anatomical bony arrangement of the clubfoot deformity radiologically and to correlate this arrangement with the Pirani clinical scoring system. This is a descriptive, cross sectional, multicentre study. Data were collected using structured questionnaire, Pirani scoring system and dorsoplanter (DP) and lateral (L) Foot radiology. Four radiological angles were measured at the intersection between the long axis of the talus and 1st metatarsal (TMT) on both views to measure the forefoot adduction and cavus, the long axis of the talus with that of the calcaneum on the (DP) view to assess the hindfoot varus and the long axis of the tibia with that of the calcaneum for the hindfoot equinus. Statistical package for social sciences (SPSS) used to analyse the data and its significance. The demographic distribution of the data showed male to female ratio of 1.6:1 and the bilateral involvement was found in half of the cases. From these angles, the dorsoplantar and lateral views talo-1st metatarsal angle were found significantly correlating with the clinical score, whereas, the other two measures for the equinus and varus were not. This study recommends conduction of further studies to address other parameters and combine both the clinical assessment and the x-ray measurement in one score to classify the severity of the deformity and the management options accordingly.
دراسة تشريحية للترتيب العظمي في الحنف القفدي الحفيي الخلقي وربط النتائج مع مقياس (بيناري) للكشف السريري للقدم : عن طريق الأشعة السينية دراسة متعددة المراكز
ديسمبر 2016 – أكتوبر 2017
مصطفى حيدر الهادي بابكر

الحنف القفدي الحفيي الخلقي (Talipes equino varus) هو من أكثر تشوهات القدم حدوثا بنسبة 1 لكل 1000 ولادة، كما يعد أكثر شيوعًا في الذكور من الإناث مع أحيال الإصابات في القدمين بنسبة تقارب النصف. وهو يصف انحناء الجزء الأمامي للداخل مع زيادة في تقوس القدم. وواهدية الرئيسي من هذه الدراسة هو تقييم الترتيب العصبي التشريحي لتشوه القدم باستخدام الصور الشعاعية وربط هذا الترتيب مع نظام الكشف السريري لبيراني. وهي طريقة للتقييم السريري موثوق بها. وقد أجريت هذه الدراسة الوصفية في مراكز متعددة. تم جمع البيانات باستخدام استبان المنظم. كما تم تطبيق مقياس بيراني السريري. كل الحالات المحترقة أجري لها فحص للقدم بالأشعة السينية لتقييم تشريح العظام. تم ترميز البيانات التي تم الحصول عليها ودخلت في تحليل الكمبيوتر باستخدام الحزمة الإحصائية للعلوم الاجتماعية. وقد استخدمت أربع زوايا لقياس كل مكون من التشوه وهي الزاوية بين عظم الكاحل والعظم الأول في واسط القدمева.Heading 3

النتائج

الاختيار النهائية للتشوه في كلا القدمين، تشتهر الإضاءة الأمامية وعظام القدم، وعظام القدم في الصور الشعاعية، في حين أن القياسات الأخرى للفخذ والقدم لم تكن ذات دالاً إحصائياً. وقد أظهرت النتائج، في حين أن الفحوصات الأخرى للقدم، في حين أن القياسات الأخرى للفخذ والقدم، لم تكن ذات دالاً إحصائياً. وقد تطابقت النتائج مع القياسات الأولية لشروط المراجع في الأدبيات. أوصت الدراسة بإجراء مزيد من الدراسات لجمع بيانات كل من التقييم التشريحي باستخدام عدة طرق واستخدام الصور الشعاعية كمعايير في قياس واحد.
# TABLE OF CONTENTS:

1. **CHAPTER ONE: INTRODUCTION** .................................................1
   1.1. Background.............................................................................1
   1.2. Problem identification ......................................................3
   1.3. Justification .........................................................................3
   1.4. OBJECTIVES .........................................................................4
       1.4.1. Main Objective ..............................................................4
       1.4.2. Specific Objectives .....................................................4

2. **CHAPTER TWO: LITERATURE REVIEW** .................................5
   2.1 Development Of The Foot ....................................................6
   2.2 Gross Anatomy Of The Foot ................................................7
       2.2.1 Foot Bone Anatomy ......................................................7
       2.2.2 Gross Anatomy of Tarsal Bones .................................8
       2.2.3 Gross Anatomy of the Metatarsus Bones: .................8
   2.3 Clubfoot ..............................................................................9
   2.4 Pirani Scoring .....................................................................13
   2.5 Imaging Studies ..................................................................14

3. **CHAPTER THREE: Materials and Methods** .........................16
   3.1 **Materials** ..........................................................................16
       3.1.1 Study Design: ...............................................................16
       3.1.2 Study Area: .................................................................16
       3.1.3 Study Population: .........................................................16
       3.1.4 Study Period: ...............................................................16
       3.1.5 Inclusion Criteria: .........................................................16
       3.1.6 Exclusion Criteria: .........................................................16
       3.1.7 Requirements: ..............................................................16
       3.1.8 Imaging Acquisition ......................................................16
       3.1.9 The X-ray scanner ........................................................17
   3.2 **Methods:** ...........................................................................17
       3.2.1 Study Methods Description: .........................................17
       3.2.2 The Pirani Scoring System: ..........................................17
       3.2.3 The radiological angles measurement: .....................17
       3.2.4 Sample size: .................................................................20
       3.2.5 Data Collection: ............................................................20
       3.2.6 Statistical Analysis: .......................................................20
       3.2.7 Ethical Consideration: ..................................................20

4. **CHAPTER FOUR: RESULTS** ..................................................21
   4.1 The demographic description ..........................................21
   4.2 Age Distribution: ...............................................................21
   4.3 The Gender Distribution: ..................................................22
4.4 Laterality of the Condition: -------------------------------22
4.5 The Radiological Angles Measurement: ------------------23
4.6 Midfoot Cavus: ----------------------------------------23
4.7 The Forefoot Adduction: -------------------------------24
4.8 The Hindfoot Varus: ------------------------------------24
4.9 The Hindfoot Equinus: --------------------------------------25
5. CHAPTER FIVE: DISCUSSION---------------------------------26
6. CONCLUSION AND RECOMMENDATION --------------------------29
   Conclusion: ---------------------------------------------29
   Recommendations: ------------------------------------------29
7. References:-----------------------------------------------30
8. Annexes -----------------------------------------------37
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>NO.</th>
<th>Figure title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Left foot DP X-ray shows A; Talo-first metatarsal angle in patient with CTEV.</td>
<td>18</td>
</tr>
<tr>
<td>3.2</td>
<td>Right foot DP view X-ray showing the Talo-calcaneal angle in patient with CTEV</td>
<td>18</td>
</tr>
<tr>
<td>3.3</td>
<td>Left foot lateral view X-ray show A; the Talo-first metatarsal (Meary’s) angle.</td>
<td>19</td>
</tr>
<tr>
<td>3.4</td>
<td>Right foot lateral view X-ray showing the Tibio-calcaneal angle in patient with CTEV.</td>
<td>19</td>
</tr>
<tr>
<td>4.1</td>
<td>Showed the distribution of patient with CTEV according to age.</td>
<td>21</td>
</tr>
<tr>
<td>4.2</td>
<td>a graph showing the distribution of gender</td>
<td>22</td>
</tr>
<tr>
<td>4.3</td>
<td>a graph showing the laterality of the condition</td>
<td>22</td>
</tr>
</tbody>
</table>
**LIST OF TABLES**

<table>
<thead>
<tr>
<th>table</th>
<th>Table title</th>
<th>Page number</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Showing the distribution of patient with CTEV according to age.</td>
<td>21</td>
</tr>
<tr>
<td>4.2</td>
<td>Table showing the distribution of the condition according to which side is involved</td>
<td>23</td>
</tr>
<tr>
<td>4.3</td>
<td>Table showing the correlation between the Pirani clinical score value and the degree of the lateral talo-1st metatarsal angle.</td>
<td>24</td>
</tr>
<tr>
<td>4.4</td>
<td>Showing the correlation between the Pirani clinical score value and the degree of the dorsoplantar talo-1st metatarsal angle.</td>
<td>24</td>
</tr>
<tr>
<td>4.5</td>
<td>Showing the correlation between the Pirani clinical score value and the degree of the dorsoplantar talocalcaneal angle.</td>
<td>25</td>
</tr>
<tr>
<td>4.6</td>
<td>Table showing the correlation between the Pirani clinical score value and the degree of the lateral Tibio-calceneal angle.</td>
<td>25</td>
</tr>
<tr>
<td>8.1</td>
<td>Different structures of the lower extremities age of appearance</td>
<td>39</td>
</tr>
</tbody>
</table>
## LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>abbreviation</th>
<th>Medical term</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTEV</td>
<td>Congenital Talipes Equinovarus</td>
</tr>
<tr>
<td>AP</td>
<td>Anteroposterior</td>
</tr>
<tr>
<td>DP</td>
<td>Dorsoplantar</td>
</tr>
<tr>
<td>TPS</td>
<td>Total Pirani Score</td>
</tr>
<tr>
<td>HCFS</td>
<td>Hind Foot Contracture Score</td>
</tr>
<tr>
<td>MFCS</td>
<td>Mid Foot Contracture Score</td>
</tr>
<tr>
<td>TCA</td>
<td>Talo-Calcaneal Angle</td>
</tr>
<tr>
<td>TMT</td>
<td>The Talo-First Metatarsal Angle</td>
</tr>
<tr>
<td>AP-TCA</td>
<td>Anteroposterior Talo-Calcaneal Angle</td>
</tr>
</tbody>
</table>
CHAPTER ONE

INTRODUCTION

1.1. Background:

Idiopathic congenital talipes equinovarus (CTEV), or clubfoot, is a common developmental disorder of the lower limb, which affects at least 1-2 per 1000 of births worldwide “Gibbons, PJ. Gray, K 2013”, one-fourth of them have a family history of the birth defect “Parker SE et al 2009”. It is described as a fixation of the foot in adduction, supination and varus, with concomitant soft tissue abnormalities. Despite advances in treatment, disability often persists “Miedzybrodzka Z. 2003”.

During the intrauterine life the lower limb buds appear around the 4th embryonic week, the skeleton of the feet starts to develop through endochondral ossification and continues to mature after birth, with the calcaneus appear at 6 month of fetal life followed by the talus and the cuboid. The navicular is the last bone to ossify between 2nd and 5th years. “Evans, Angela et al, 2010”.

although Idiopathic Clubfoot (CTEV) is one of the oldest and commonest musculoskeletal anomalies known to mankind but a lot of controversy still exist regarding the aetiology, pathologic anatomy, classification, treatment, and evaluation criteria. “Trivedi V, 2017”.

Irrespective of the aetiology, most of the literature agreed that the description of the condition is uniform for the most part “Fukuhara K et al, 1994” which is forefoot supination and adduction with the midfoot in cavus (high arched foot), and the hind foot in Varus (an inward angulation) and Equines (insufficient ankle joint dorsiflexion). “Anand A,Sala D 2008; Fukuhara K et al, 1994”.

Although the deformity doesn’t cause pain to the child, it leads to disability in walking later in life especially those affected bilaterally. The severity can range from mild flexible which can be corrected conservatively using serial casting manipulation to the severely rigid form that required surgical intervention. “Gray K, et al 2014; Baghdadi T et al 2017”. Different criteria to assess the severity of deformity, its progression and to evaluate the results of treatment have been advocated. “Wainwright 2002” Jain A et al 2001” “Lehman WB et al 2003”.

To address this severity clinically different assessment methods were used, which are: The systems of Ponseti and Smoley 1963, Harrold and Walker 1983, Catterall 1991, Diméglio scoring system “Diméglio A et al 1995” and the Pirani clinical score “Pirani S et al 1999”. The Dimeglio and Pirani systems, both apply a point score based on a number of different physical findings remain the most widely accepted clubfoot severity grading systems. Although they were found to be correlated with the severity of the condition “Flynn JM et al, 1998” However, their prognostic value remains questionable, at least in the early treatment stages “Gao R et al 2014”. And some authors recommends their simultaneous use “Cosma D, Vasilescu DE 2015”.

Unlike many other clubfoot scoring systems, The Pirani scoring system has been found to be both valid and reliable ”Pirani S, 2003”. Pirani scoring system has found wider acceptance before, during and after treatment. It is used to differentiate between lesions and compare treatment results. The score is quick, reliable easy to memorize and it is an easy to use tool for assessing the severity of each of the components of a clubfoot “Cosma D, Vasilescu DE 2015” “Dyer P, Davis N 2006”.

The underlying bony anatomy of the deformity was still altered even after clinical correction this suggested the use of other method to assess the condition One of these methods was the radiological assessment of the deformity ”Bansal VP, et al 1988”. However, the utility of radiographic methods and their relationship to clinical outcome is still being debated “Joseph B et al 2001” “Moses W et al 2000” “Cohen-Sobel E et al 1993” “Roye BD et al 2001” “Uglow MG, Clarke NMP 2000”.

Correspondingly, the literature shows different opinions regarding whether is there any significance between the radiological parameter and the clinical function of the foot. From those who address the significance of these relation fail to address a certain reliable parameters, so large number of parameters have been described in an effort to facilitate definition of the anatomical deviations, in AP and lateral X-Ray images “Prasad P et al, 2009”.

Some of the reported articles “Thompson GH et al, 1982” “Cooper DM, Dietz FR, 1995” “Hutchins PM et al, 1985” “Beatson TR, Pearson JR, 1966” considered only or few radiological parameters as the most reliable indicators for assessment of clubfoot. Other studies addressed the all possible radiological parameters in relation to the various deformities “Prasad P et al, 2009” as shown in the (Annex 3).

In respective to the previously mentioned studies this study addressed the five components of the deformity by measuring 4 radiological parameter on AP and lateral foot x-ray bearing in mind that the forefoot supination and adduction assessed collectively as some authors referred to the combined deformities of adduction and supination as “varus” “George
W, 1977”. These four radiological parameter are the talo-first metatarsal angle on the DP describing the intersection of the long axis of the talus with the long axis of the first metatarsal bone to measure the forefoot adduction “Simons G.W. 1978”. The tibio-calcaneal angle on lateral view describing the intersection of the long axis of the tibia with the long axis of the calcaneum on standing position to measure the Equinus “Prasad P et al, 2009”. The Talo-calcaneal angle DP view describing the intersection of the long axis of the talus with the long axis of the calcaneum to measure the hind-foot Varus “Wisbrun 1932; Davis and Hatt 1955”; “Heywood 1964”. The talo-first metatarsal angle on lateral view (Meary’s angle) “Banks AS et-al 2001” describing the intersection of the long axis of the talus with the long axis of the first metatarsal to measure the degree of midfoot Cavus.

1.2. Problem Identification

Clubfoot (Congenital Talipes Equino Varus (CTEV)) is a common developmental anomaly and high ambiguity in respect to pathologic anatomy, aetiology, classification of severity, treatment, and evaluation still exist.

1.3. Justification:

Congenital Talipes Equino Varus is a frequent presentation, which causes severe agony to the parents.

It’s commonly bilateral, and most cases attend the clinic late, which makes it harder for the child to walk normally.

High ambiguity is detected in the structural basis of CTEV.

This research highlights the significance of applied anatomy. In this respect, the radiographic assessment of the deformity causes much debate and controversy.

The Pirani scoring system is a clinical score which depends on the subjective assessment of the clinicians.

The prognostic value of the Pirani score is found to be questionable.
1.4. Objectives:

1.4.1. Main Objectives:

This study tended to evaluate the anatomical bony arrangement of clubfoot deformity radiologically and to correlate this arrangement with the Pirani clinical scoring system.

1.4.2. Specific Objectives:

The specific objectives aim to measure:

- The adduction by the degree Talo-first metatarsal angle on the AP X ray images.
- The degree of Cavus by Talo-first metatarsal angle on lateral X ray view.
- The Equinus using the Tibio-calcaneal angle on lateral view.
- The hind-foot Varus by the Talo-calcaneal angle lateral X-ray view.
- The age distribution at presentation for patent with CTEV.
- The gender distribution among patent with CTEV.
- The laterality of the condition among patents with CTEV.
CHAPTER TWO
LITERATURE REVIEW

Clubfoot is a fairly common birth defect and is usually an isolated problem for an otherwise healthy newborn. It had been described by Hippocrates in the year 400 BC and since then it has been a source of debate and challenge for paediatric orthopaedic surgeons, because the exact cause is not well defined “Kite JH.1964” “Anand A, Sala DA.2008”.

Clubfoot describes a range of foot abnormalities, usually presents at birth (congenital) in which baby's foot is twisted out of shape or position. Not all clubfeet are the same and it is important that all people treating clubfoot use the same terms to describe the different types. Yet it can be mild or severe. About half of children with clubfoot have it in both feet, makes it harder for the child to walk normally, so doctors generally recommend treating it as soon as possible after birth. “Zionts LE 2015”

The causes of clubfoot are not clearly understood. Most commonly, it was classified as “Idiopathic Clubfoot” which means there is no known cause and “Secondary Clubfoot” which occurs when there is another disease or condition that is causing or is linked to the clubfoot, such conditions are usually neurological or syndromic disorders such as Arthrogryposis or Spina Bifida. “Dobbs M.B, Gurnett, C.A. 2009; Africa Clubfoot Training Project, 2017a”.

There is also a condition known as “Positional Clubfoot”, which is not really a true clubfoot as the foot is fully correctable. “Africa Clubfoot Training Project, 2017b”.

2.1 Development of the Foot

The development of the limb start at 6-9 mm stage, a transient apical epidermal ridge which is critical to maintaining limb outgrowth appears. Its removal results in truncation of the limb. Internal limb tissue differentiation (bone, muscle) continues through the fetal period and into postnatal development. (Annex 5) Outgrowth continues into the fifth week (11-13 mm embryo)” Eric K, Cecilia 2016”.

The musculoskeletal system consists of skeletal muscle, bone, and cartilage and is mainly mesoderm in origin with some neural crest contribution. (Annex 6) and (Annex 7)” Eric K, Cecilia 2016”.

Morphologically, the foot is divided into two cranial (preaxial) and caudal (postaxial) regions linked with the tibia and fibula.” Eric K, Cecilia 2016”. 
a) **The Preaxial Region**: (comprises the second ray) and the talus, navicular, and cuneiforms.

b) **The Postaxial Region**: (comprises the third ray), cuboid, and calcaneus. In the 14 mm embryo, the foot will continue to develop so that the 5 rays evolve into a more fanlike structure.

Skeletal muscle forms by fusion of mononucleated myoblasts to form multinucleated myotubes. Bone is formed through a lengthy process involving ossification of a cartilage formed from mesenchyme. Two main forms of ossification occur in different bones, intramembranous (e.g. skull) and endochondrial (e.g. limb long bones) ossification. “Eric K, Cecilia 2016”.

Intrauterine development of the lower extremity consists of outgrowth, rotation, and regional morphologic development of structure (thigh, leg, and foot). (Annex: Table 8.1)

In the seventh week (22-24 mm), both feet are nearly sagittal in orientation. The end of the eighth week signifies the end of the embryonic period and the beginning of the fetal period. All of the adult structures are in place” Eric K, Cecilia 2016”.

---

2.2 **Gross Anatomy Of The Foot**

2.2.1 **Foot Bone Anatomy**

The human foot is a highly developed, biomechanically complex structure that serves to bear the weight of the body as well as forces many times the weight of the human body during thrust. “Vinod K, Panchbhavi MD 2015”.

About 26 bones in the human foot provide structural support. They can be grouped into 3 parts, as follows:

- The tarsal bones (7)
- The metatarsal bones (5)
- The phalanges (14) “Vinod K, Panchbhavi MD 2015”.

The foot itself can be divided into 3 parts: (Annex 6) & (Annex 7)

- **The Hind-foot**: Composed of 2 of the 7 tarsal bones, the talus, and the calcaneus.
- **The Mid-foot**: Contains the rest of the tarsal bones.
- **The Fore-foot**: Contains the metatarsals and the phalanges “Vinod K, Panchbhavi MD 2015”.
2.2.2 Gross Anatomy of Tarsal Bones

The tarsus (posterior or proximal foot; hindfoot + midfoot) consists of seven bones: talus, calcaneus, cuboid, navicular, and three cuneiforms.

The talus (L., ankle bone) has a body, neck, and head. (Annex 10) (Annex 11) The superior surface, or trochlea of the talus, is gripped by the two malleoli and receives the weight of the body from the tibia. The talus transmits and divide the weight in turn via an osseoligamentous “Hammock” (spring ligament) that receives the rounded and anteromedially directed head of talus. “Moore, K.L 2013”.

The talus is the only tarsal bone that has no muscular or tendinous attachments. Most of its surface is covered with articular cartilage.

The calcaneus (L., heel bone) is the largest and strongest bone in the foot. It transmits the majority of the body’s weight from the talus to the ground when standing.. It anchors a tendon pulley for muscles that move the sole of the foot away from the median plane (the evertors of the foot). The posterior part of the calcaneus has a massive, weight-bearing prominence, the calcaneal tuberosity. (Annex 12, Annex 13, Annex 14) “Moore, K.L 2013”.

The navicular (L., little ship) is a flattened bone located between the head of the talus posteriorly and the three cuneiforms anteriorly. (Annex 15, Annex 16) “Moore, K.L 2013”.

The cuboid, approximately cubical in shape, is the most lateral bone in the distal row of the tarsus. (Annex 8, Annex 9) “Moore, K.L 2013”.

The three cuneiform bones are the medial (1st), intermediate (2nd), and lateral (3rd). The medial cuneiform is the largest bone. (Annex 8, Annex 9) “Moore, K.L 2013”.

2.2.3 Gross Anatomy of the Metatarsus Bones:

The metatarsus (anterior or distal foot, forefoot) consists of five metatarsals that are numbered from the medial side of the foot. The bases of the metatarsals articulate with the cuneiform and cuboid bones, and the heads articulate with the proximal phalanges. The bases of the 1st and 5th metatarsals have large tuberosities that provide for tendon attachment. (Annex 8, Annex 9) “Moore, K.L 2013”.

7
2.3 Clubfoot

Club foot (congenital talipes equinovarus CTEV) is a congenital deformity where one foot or both appear to have been rotated internally at the ankle. Approximately half of people with clubfoot have it bilaterally. In most cases it is an isolated disorder of the limbs. It occurs in males twice as frequently as in females. (Annex 1) “Gibbons, PJ; Gray, K 2013”.

Clubfoot can be classified as either of the following:

- **Postural or positional** - Technically, these are not true clubfeet
- **Fixed or rigid** - These are either:
  - Flexible (i.e., correctable without surgery) or
  - Resistant (i.e., requiring surgical release, though this is not entirely true according to the Ponseti experience) “Docker CE, et al 2007” “Scher DM 2006”.

The Pirani, Goldner, Di Miglio, Hospital for Joint Diseases (HJD), and Walker classifications have been published, but no classification system is universally used. “Hussain FN 2007; Lejman T, Kowalczyk B 2002; Kaewponsawan K et al 2007”.

In the past, clubfoot surgery was performed in a way that did not differentiate severity. The same procedure was performed for all patients. Bensahel proposed a more individualized approach in which the surgery is tailored to the deformity. “Celebi L 2006”.

2.3.1.1 Anatomy in Clubfoot

Factors related to bone anatomy include the following:

- **Tibia** - Slight shortening is possible
- **Fibula** - Shortening is common
- **Talus** - In equinus in the ankle mortise, with the body of the talus being in external rotation, the body of the talus is extruded anterolaterally and is uncovered and can be palpated; the neck of the talus is medially deviated and plantarflexed; all relations of the talus to the surrounding bones are abnormal
- **Os calcis** - Medial rotation and an equinus and adduction deformity are present
- **Navicular** - The navicular is medially subluxated over the talar head
- **Cuboid** - The cuboid is medially subluxated over the calcaneal head
- **Forefoot** - The forefoot is adducted and supinated; severe cases also have cavus with a dropped first metatarsal. “Minoo P, John H 2017”

Factors related to muscle anatomy include the following:

- Atrophy of the leg muscles, especially in the peroneal group, is seen in clubfeet
- The number of fibers in the muscles is normal, but the fibers are smaller
The triceps surae, tibialis posterior, flexor digitorum longus, and flexor hallucis longus are contracted.

The calf is smaller and remains so throughout life, even after successful long-lasting correction of the feet.

Thickening of the tendon sheaths frequently is present, especially of the tibialis posterior and peroneal sheaths.

Contractures of the posterior ankle capsule, subtalar capsule, and talonavicular and calcaneocuboid joint capsules commonly are seen. Contractures are seen in the calcaneofibular, talofibular, (ankle) deltoid, long and short plantar, spring, and bifurcate ligaments. The plantar fascial contracture contributes to the cavus, as does contracture of fascial planes in the foot “Minoo P, John H 2017”.

### 2.3.1.2 Pathophysiology

Various theories of the pathogenesis of clubfeet have been advanced, including the following:

- Arrest of fetal development in the fibular stage
- Defective cartilaginous anlage of the talus
- Neurogenic factors
- Retracting fibrosis
- Anomalous tendon insertions
- Seasonal variations

With respect to neurogenic factors, histochemical abnormalities have been found in posteromedial and peroneal muscle groups of patients with clubfeet. This is postulated to be due to innervation changes in intrauterine life secondary to a neurologic event, such as a stroke leading to mild hemiparesis or paraparesis. This is further supported by a 35% incidence of varus and equinovarus deformity in spina bifida “Minoo P, John H 2017”.

Retracting fibrosis (or myofibrosis) may occur secondary to increased fibrous tissue in muscles and ligaments. In fetal and cadaveric studies, Ponseti also found the collagen in all of the ligamentous and tendinous structures (except the Achilles [calcaneal] tendon), and it was very loosely crimped and could be stretched. The Achilles tendon, on the other hand, was made up of tightly crimped collagen and was resistant to stretching. Zimny et al found myoblasts in medial fascia on electron microscopy and postulated that they cause medial contracture. “Zimny ML et al 1985”.

9
Inclan proposed that anomalous tendon insertions result in clubfeet. "Inclan 1958". However, other studies have not supported this proposal. It is more likely that the distorted clubfoot anatomy can make it appear that tendon insertions are anomalous. Robertson noted seasonal variations to be a factor in his epidemiologic studies in developing countries. This coincided with a similar variation in the incidence of poliomyelitis in the children in the community. Clubfoot was therefore proposed to be a sequela of a prenatal poliolike condition. This theory is further supported by motor neuron changes in the anterior horn in the spinal cord of these babies.

### 2.3.1.3 Aetiology

The true aetiology of congenital clubfoot is unknown. Today a number of hypotheses remain, including the following:

- Uterine restriction,
- Abnormalities of joint and/or bone formation,
- Connective tissue,
- Distal limb vasculature,
- Neurological development,
- Muscle migration
- An underlying developmental abnormality or developmental arrest.

Most infants who have clubfoot have no identifiable genetic, syndromal, or extrinsic cause “Parker SE 2009”. Extrinsic associations include teratogenic agents (e.g., sodium aminopterin), oligohydramnios, and congenital constriction rings. Genetic associations include mendelian inheritance (e.g., diastrophic dwarfism; autosomal recessive pattern of clubfoot inheritance).

It has been proposed that idiopathic CTEV in otherwise healthy infants is the result of a multifactorial system of inheritance “Paton RW, Freemont AJ. 1993”.

### 2.3.1.4 Epidemiology

The incidence of clubfoot is approximately 1 case per 1000 live births in the United States. The incidence differs among ethnicities. For example, it is close to 75 cases per 1000 live births in the Polynesian islands, particularly in Tonga. A prospective study was conducted of all congenital anomalies presenting at the neonatal unit at Queen Elizabeth Central Hospital, Banter, Malawi in two years’ time, the number of children with clubfoot deformity recorded was 64 or 1 in 496 births, translating to 2 per 1000 births. Mkandawire, N.C.2004. The male-to-female ratio has been reported to be 2:1. Bilateral involvement is found in 30-50% of cases. In 2017 study by Zionts et al found that severity did not differ significantly by either
sex or bilaterality, though patients with bilateral clubfoot had a wider range of severity.” Zionts LE et al 2017”.

Approximately 80% of these will be in low- and middle-income countries. Most will not receive effective treatment and will grow up with severe disability “Werler MM, et al 2013”

2.3.1.5 Prognosis

Approximately 50% of clubfeet in new-borns can be corrected non-operatively. Surgical prognostic outcomes is quite variable, reported as high as 89% to a low success rate of 10-35%. Chaudhry S, et al 2012. The range of ankle movement was a major factor in determining the functional result.

Recurrence rates of deformity were reported to be around 25%, with a range of 10-50%. “Ponseti IV 2000; Haft GF et al 2007”,

The age at operation is directly related to the result, with the best results were obtained with children older than 3-4 months. “Simons GW. 1995”

2.3.1.6 Clinical Presentation

The condition is diagnosed clinically, The feet examined with the child prone, with the plantar aspect of the feet visualized, and supine to evaluate internal rotation and varus. If the child can stand, one should determine whether the foot is plantigrade, whether the heel is bearing weight, and whether it is in varus, valgus, or neutral. “Minoo P, John H 2017”

The ankle in equinus, and the foot is supinated (varus) and adducted, Contractures of the medial plantar soft tissues are present. Not only is the calcaneus in a position of equinus, but also the anterior aspect is rotated medially and the posterior aspect laterally. “Minoo P, John H 2017”

The heel is small and empty. The heel feels soft to the touch. As the treatment progresses, it fills in and develops a firmer feel, The talar neck is easily palpable, the medial malleolus is difficult to palpate and is often in contact with the navicular. The normal navicular-malleolar interval is diminished. Despite its look, however, clubfoot itself doesn't cause any discomfort or pain. “Minoo P, John H 2017”

2.3.1.7 Investigations

Talipes was previously only diagnosed after a baby is born. However, as the technology of ultrasound scanning during pregnancy improves, increasingly, talipes is being detected during scanning before a baby is born.

Investigations such as X-rays are not usually needed to confirm the diagnosis. However, imaging is helpful in order to define severity and to monitor progress of treatment. “Minoo P, John H 2017”
2.4 **Pirani Scoring**

Based on the clinical description multiple methods of assessment were described in an effort to facilitate the examination of the deformity and to grade its severity. One of these methods was described by Pirani et al. 1999 widespread use today in foot and ankle surgical practice. Pirani scoring system has found wider acceptance before, during and after treatment. It is used to differentiate between lesions and compare treatment results, during and after treatment. The score is quick, reliable easy to memorize and it is an easy to use tool for assessing the severity of each of the components of a clubfoot. Even after clinical correction the underlying bony anatomy was still altered. “Cosma D, Vasilescu DE 2015” “Dyer P, Davis N 2006”.

The Pirani score is extremely useful for assessing the severity of the clubfoot at presentation and for monitoring patients’ progress. This score should be recorded at each visit the patient makes. If the score increases from one visit to the next it may indicate that a relapse of deformity is occurring.

The components are scored as follows:

Each component may score 0, 0.5 or 1 (Annex 4)”pirani S 2003”

**Hind foot contracture score (HCFS):**
1. Posterior crease
2. Empty heel
3. Rigid equinus

**Mid foot contracture score (MFCS):**
1. Medial crease
2. Curvature of lateral border
3. Position of head of talus

It is useful for predicting treatment outcomes; a higher score on presentation may indicate that a higher number of casts will be required. “Dyer P, Davis N 2006”; Gao R et al 2014” Children with initial high HFCS may be more likely than those with lower scores to experience relapse of deformity during the bracing phase “Goriainov V, Uglow M 2010”. They should therefore be monitored carefully.

The clinical score is used to predict the different management procedures. “Badmus H 2017”: The indication for tenotomy as a management technique appears to be well predicted using the Pirani scoring system. Low Pirani means that the patient will not require tenotomy procedures, while high Pirani means the patient will require tenotomy. The total pirani score
(TPS) of 4.75 is a cut-off point, above or below which the requirement for certain type management. “Badmus H 2017”

Dyer and Davis in agreement with Scher DM et al, 2004 study indicated the role of the Pirani scoring system in the management of clubfoot. Children with clubfeet who have an initial score of > or = 5.0 by the Pirani system or are rated as Grade IV feet by the Dimeglio system are very likely to need a surgical tenotomy.

The assessment of clubfoot during serial manipulation is mainly done clinically with various scoring system. Even after clinical correction the underlying bony anatomy was still altered “Arijit. D et al, 2017”.

Scoring commonly employed to grade the foot prior to and during treatment has been proven to be a good clinical tool as it is reliable, valid and responsive to change. Clinically, the tool can be used to measure the degree of deformity of each element of the affected foot, to assess if the deformity is correcting as predicted or not.

The use of clinical evaluation alone has been found to be an unsatisfactory method of differentiation, particularly when based only on subjective assessment. “V. P. Bansal et al.1988”.

2.5 Imaging Studies

Imaging studies generally are not required to understand the nature or the severity of the deformity. Radiography, however, provides a useful baseline before and after surgical correction of the feet for either closed Achilles tenotomy, or a limited posterior release. Radiographs show the true gain in foot (ankle) dorsiflexion and confirm the appearance of an iatrogenic rocker bottom foot should one result. Occasionally, radiographs are necessary to diagnose clubfeet associated with tibial hemimelias “Minoo P, John H 2017”.


Whereas some articles have commented on statistically significant correlations between radiographic results and function “Prasad P et al 2009”

As Laaveg SJ, and Ponseti IV in 1980 summarize this correlation by stating that “The amount of motion in the joints of the foot and ankle and the correction of the lateral talocalcaneal angle correlated with the degree of patient satisfaction and the functional rating of the club foot. And then “Thompson GH et al, 1982; mention that: The radiographic measurements that correlated best with the clinical results were the anteroposterior
talocalcaneal overlap, the lateral talocalcaneal angle, and the positions of the navicular and calcaneus.

“Yamamoto H, Furuya K.1988” in relation to the clinical result stated that: The relationship between these results and angles measured from roentgenograms was analysed using multiple regression. The results showed a closer relationship to the anteroposterior talocalcaneal angle, the tibiocalcaneal angle, and the MTR angle.

While others have found no relationship between the two as “Cooper DM, Dietz FR. 1995” stated that: The outcome could not be predicted from the radiographic result. Herbsthofer B and his colleagues in 1998 after studying 38 patient post-surgery for the correlation between the two conclude that: A correlation of clinical severity grading with the measured angular dimensions was not possible due to measurement imprecision and the range of values occurring within the different severity groups.

Even among the studies stating significant relationships, there is little concordance of results. For example, “Laaveg SJ, Ponseti IV.1980” and “Hutchins PM et al 1985” found that the talo-calcaneal angle (TCA) correlated with function, but other authors “Cooper DM, Dietz FR 1995 and Herbsthofer B, et al 1998” failed to reproduce the same. “Yamamoto H, Furuya K. 1988“ found that AP, but not the lateral TCA, correlated with functional rating, whereas “Laaveg SJ, Ponseti IV.1980“ and “Thompson GH et al 1982” found that the lateral TCA but not the AP-TCA correlated with their clinical measures. “Prasad P, 2009”

In respective to “Prasad P, 2009” who considered twelve different parameters in both AP and lateral views, representing each of the various deformities in his study, here this study meant to address single parameter for each deformity which was considered accurately accepted.

As stated by George W. and Simons, in 1977: The **talocalcaneal angle** in the anteroposterior view. An angle of less than 20 degrees indicates hind foot varus (Annex 2) “George W. et al 1977”

The talo-first metatarsal angle (TMT angle) on the antero-posterior view with a normal value between zero to -20 degrees; measurements in a positive direction are abnormal. This angle is not a pure measurement, but indicates medial deviation of the foot at either the distal or proximal row of tarsal joints or both, and as such is not particularly helpful, but it becomes quite helpful when it is used in conjunction with the talo-calcaneal angle”. This was considered satisfactory measure to fore-foot adduction by “Laaveg SJ, Ponseti IV.1980” “Prasad P, 2009”
Because the other angle to address the forefoot adduction was the metatarsus adductus angle which depend on the distal raw of the tarsal bone to be accurately measured which start ossification between second to fifth years of life. “Sgarlato T 1971” “Engle E et al 1983”

**The tibio-calcaneal** angle with the ratio 60-90 was use as a measure for the hindfoot equinus. It’s a simple reliable parameter to assess the clubfoot dorsiflexion as stated by “Kang S, Park SS 2015”.

**Meary's angle** or **lateral talo-first metatarsal angle** has been used to identify the apex of deformity in patients heigh arched foot “pes cavus” which indicated by increased angle, in normal weight-bearing foot the midline axis of the talus is in line with the midline axis of the first metatarsal. Normally Meary's angle is 0 – 4 degree. “Banks AS et-al.2001” “Herring JA. 2013”

The position of the patient is one of the difficulties in obtaining the accurate radiological measures, this was solved by “George W. Simons, 1977” using their standard technique which described that the best X-ray obtained preoperatively after induction of anaesthesia, with the child’s hip and knee are flexed and the beam is parallel to the long axis of the tibia when obtaining the dorsoplantar view radiograph, the same applied to the lateral view using cardboard to achieve the maximum dorsiflexion “George W. Simons, 1977”.
CHAPTER THREE
MATERIALS AND METHODS

3.1 Materials

3.1.1 Study Design:
This a descriptive cross-sectional hospital-based study.

3.1.2 Study Area:
The study was conducted as multi-centres study. These centres were Omdurman Teaching Hospital, Gezira Traumatology Centre and Soba University Hospital (Paediatric Orthopaedic Centre).

3.1.3 Study Population:
All patients with congenital clubfoot CTEV attending the referred clinics in the study areas, during the study period.

3.1.4 Study Period:
This study was conducted in the period between the January and October 2017.

3.1.5 Inclusion Criteria:
All patients with congenital clubfoot deformity males and females whom their parents agreed to be recruited in the study.

3.1.6 Exclusion Criteria:
Children on conservative cast or already had surgery.
Children whose parents refused to participate in the study.

3.1.7 Requirements:
Those patients were examined in the referral clinics after verbal consent from the parents was obtained, personal information were collected using a structured precoded questionnaire (Annex 8.4). Clinical assessment of the affected limb using the Pirani clinical score was performed for all candidates. X-ray images of the affected limb were taken.

3.1.8 Imaging Acquisition
Plane X-Ray of the affected foot was taken using two views the DP and lateral view, using a standard technique describing the DP view is taken with the hip and knee flexed and the ankle on maximum dorsiflexion and the X-ray beams are neutral to the long axis of the tibia.
The lateral view was taken in a same position only using a Cardboard to obtain the dorsiflexion of the ankle joint, each foot at a time. These x-rays were then taken and scanned in a computer to be assessed later.

3.1.9 **The X-ray scanner:**

The x-ray was taken using Digital X-Ray Machine brand name AGFA from GAMMA MEDIX for medical services. (ANNEX 17)

3.2 **Methods:**

3.2.1 **Study Methods Description:**

3.2.2 **The Pirani Scoring System:**

A clinical assessment of the child feet was done using the Pirani severity score, describing six parameters and each one was graded from 0, 0.5 or 1.

According to the total Pirani score (TPS) the candidate grouped into two category, those who have TPS < 4.5 which were considered a low severity group and those with the score of > 4.5 whose regarded as severe group.

3.2.3 **The Radiological Angles Measurement:**

Four radiological parameter obtained and calculated using the digital X-ray machine, with a normal range obtained from the literature reviewed previously, with each angle described a component of the deformity, these angles are:

- The talo-1st metatarsal angle on the DP view which describe the intersection of the long axis of the talus with the long axis of the first metatarsal bone to measure the forefoot adduction. With the normal value between 0-20, any angle more than 20 would considered a forefoot adduction (Figure 3.1) “Laaveg SJ, Ponseti IV.1980” “Prasad P, 2009”. The following figure demonstrate the angle Obtained during the research.
Figure 3.1: left foot DP X-ray of patient with CTEV showing A; Talo-first metatarsal angle, B; the long axis of the talus. B; the long axis of the 1st metatarsal bone.

- The talocalcaneal angle on the DP view which describe the intersection of the long axis of the talus with the long axis of the calcaneum to measure the hindfoot varus. With a normal value range between 25 – 40 and angle below the 25 would regards as hind-foot varus, (Annex 2) (Figure 3.2) “George W.et al 1977”. The following figure demonstrate the angle Obtained during the research.

Figure 3.2: Right foot DP view X-ray of a patient with CTEV showing A; the long axis of the calcenium. B; the long axis of the talus. C; the talo-calcaneal angle
• The talo-1st metatarsal angle on the lateral view which describe the intersection of the long axis of the talus with the long axis of the first metatarsal bone to measure the mid-foot cavus with normal range 0 - 4 degree and an increase angle above the 4 degree would be considered as cavus (Figure 3.3) “Banks AS et-al.2001” “Herring JA. 2013”. The following figure demonstrate the angle Obtained during the research.

Figure 3.3: Left foot lateral view X-ray of patient with CTEV showing A; the Talo-first metatarsal (Meary’s) angle, B; the long axis of the talus C; the long axis of the 1st metatarsal bone.

• The tibiocalcaneal angle on the lateral view which describe the intersection of the long axis of the tibia with the long axis of the calcaneum to measure the hind-foot equinus. With a normal range between 60 – 90 degree, any increase angle above the 90 degree would be regarded as equinus (Figure 3.3) “Kang S, Park SS 2015”.

Figure 3.4: Right foot lateral view X-ray of patient with CTEV showing A; the Tibio-calcaneal angle, B; the long axis of the tibia, C; the long axis of the calcaneum.
3.2.4 Sample size:

Sample size included all the patients during the research period (whole coverage) excluding those who were discarded by the exclusion criteria. The researcher didn’t use the sample formula because the prevalence of the clubfoot deformity in Sudan wasn’t known, as far as the literature was reviewed.

3.2.5 Data Collection:

Data was collected using a structured questionnaire. The questionnaire contained questions about personal data and Pirani scoring system which was applied by the researcher. (Annex 8.4)

Foot radiology obtained to assess the bone anatomical measures after consenting the parents.

3.2.6 Statistical Analysis:

The obtained data was coded and entered into a computer analysis using statistical package for social science (SPSS) version 21 manufactured by IBM. The data were ranked in two rows describing the Pirani clinical score above and below 4.5 as a cut-off point “Badmus H 2017; Scher DM et al, 2004”. The radiological parameters were categorised into four columns describing the severity as: normal, mild, moderate and severe form. Then they were assessed and correlated with Pirani clinical scoring system. Chi–square test was used to test the significant difference between the variables. A P. value of < 0.05 was considered statistically significant. The results were presented into tables and graphs.

3.2.7 Ethical Consideration:

The research follows University of Gezira - Faculty of Medicine - Anatomy Department ethical consideration. Approval from hospital’s administrator and consultants responsible for the cases was taken to conduct the research, parent informed written consent to examine the child and doing an X-ray was taken for every patient involved in the research.
CHAPTER FOUR

RESULTS

From the data obtained during the research, the total number were 16 patients with a total number of feet involved was 25. These number were analysed to obtain the demographic description of the condition, and to assess the correlation between the angle’s measures and the clinical score, the results were presented in a form of tables and graphs.

4.1. The demographic description:
4.1.1. Age Distribution:

The variation on the age at which the x-ray and the clinical assessment was done is shown figure 4.1 and table 4.1. The majority of patients (68.75%) distributed bellow the age of 6 month and with only (18.75%) of the patients presenting later than one year.

![Figure 4.1: showed the distribution of patient with CTEV according to age.](image)

<table>
<thead>
<tr>
<th>The age</th>
<th>Number of patients</th>
<th>The percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 6 month</td>
<td>11</td>
<td>68.75%</td>
</tr>
<tr>
<td>6 month – 1 year</td>
<td>2</td>
<td>12.5%</td>
</tr>
<tr>
<td>More than 1 year</td>
<td>3</td>
<td>18.75%</td>
</tr>
<tr>
<td>total</td>
<td>16</td>
<td>100%</td>
</tr>
</tbody>
</table>
4.1.2. The Gender Distribution:

The majority of the cases were male with the 62.50%. With 1.6:1 male to female ratio.

![Gender Distribution Graph]

FIGURE 4.2: a graph showing the distribution of the condition according to the gender

4.1.3. Laterality of the Condition:

The following graph and table showing the distribution of CTEV according to which foot is affected. It concluded that 56.25% of the obtained data were bilaterally affected.

![Laterality Distribution Graph]

FIGURE 4.3: a graph showing the laterality of the condition
Table 4.2: Table showing the distribution of the condition according to which side is involved.

<table>
<thead>
<tr>
<th>Affected side</th>
<th>Number of patient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>6</td>
<td>37.5%</td>
</tr>
<tr>
<td>Left</td>
<td>1</td>
<td>6.25%</td>
</tr>
<tr>
<td>Both</td>
<td>9</td>
<td>56.25%</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>100%</td>
</tr>
</tbody>
</table>

4.2. The Radiological Angles Measurement:

The following tables describing the correlation between the clinical Pirani score categorizing the data into two rows the first one is 0-4.5 describing the patients obtained TPS of less than 4.5 and the second groups who obtained TPS of more than 4.5. These data compared with angles used to describe each one of the four deformities. Which are:

- Talo-1st metatarsal DP view for the forefoot adduction.
- Talo-1st metatarsal L view for the midfoot cavus.
- Tal-calcaneal angle DP view for the hindfoot varus.
- Tibio-calcaneal angle L view for the hindfoot equinus.

4.4.1 Midfoot Cavus:

Correlating the angles on X-ray images with Pinari classification using the talo-1st metatarsal angle on the Lateral view with the normal value of 0-4 degree, and as described in the literature any degree above the 4 would be considered as midfoot cavus. These data are further classified as mid, moderate and severe. This angle shows a statistical significant correlation (P-value < 0.05).
Table 4.3: a table showing the correlation between the Pirani clinical score value and the degree of the lateral talo-1st metatarsal angle.

<table>
<thead>
<tr>
<th>Talo-1st metatarsal angle L</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pirani score</td>
<td></td>
</tr>
<tr>
<td>normal</td>
<td></td>
</tr>
<tr>
<td>0 – 4</td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td></td>
</tr>
<tr>
<td>4 - 15</td>
<td></td>
</tr>
<tr>
<td>moderate</td>
<td></td>
</tr>
<tr>
<td>15 - 30</td>
<td></td>
</tr>
<tr>
<td>severe</td>
<td></td>
</tr>
<tr>
<td>more than 30</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>percent</td>
<td></td>
</tr>
<tr>
<td>0 - 4.5</td>
<td>2</td>
</tr>
<tr>
<td>4.5 - 6</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
</tr>
</tbody>
</table>

Chi-Square Tests = .004 P. Value = .005

4.4.2 The Forefoot Adduction:

Measuring the talo-1st metatarsal angle on the DP view with a normal value ranged between the 0-20 degree and any increase above the 20 will be described as forefoot adduction, and farther classification to mid, moderate and severe accordingly. The data shows a statistical significance correlation (P-value < 0.05)

Table 4.4: showing the correlation between the Pirani clinical score value and the degree of the dorsoplantar talo-1st metatarsal angle.

<table>
<thead>
<tr>
<th>Talo-1st Metatarsal angle DP</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pirani score</td>
<td></td>
</tr>
<tr>
<td>normal</td>
<td></td>
</tr>
<tr>
<td>0-20</td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td></td>
</tr>
<tr>
<td>20-40</td>
<td></td>
</tr>
<tr>
<td>moderate</td>
<td></td>
</tr>
<tr>
<td>40-60</td>
<td></td>
</tr>
<tr>
<td>severe</td>
<td></td>
</tr>
<tr>
<td>more than 60</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>percent</td>
<td></td>
</tr>
<tr>
<td>0 - 4.5</td>
<td>3</td>
</tr>
<tr>
<td>4.5 - 6</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
</tr>
</tbody>
</table>

Chi-Square Tests = .002 P-Value = .001

4.4.3 The Hind-foot varus:

Measuring the talocalcaneal angle on the DP view, with the normal value between 25 – 40 and any degree less than 25 degree would considered hindfoot varus, with farther classification to mild moderate and severe accordingly. The data obtained showed no statistical significance (P-value > 0.05)
Table 4.5: Showing the correlation between the Pirani clinical score value and the degree of the dorsoplantar talocalcaneal angle.

<table>
<thead>
<tr>
<th>Pirani score</th>
<th>Talocalcaneal angle DP</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>normal 25 – 40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mild 20 - 25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>moderate 15 - 20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>severe less than 15</td>
<td></td>
</tr>
<tr>
<td>0 - 4.5</td>
<td>3  25.0%</td>
<td>12 48%</td>
</tr>
<tr>
<td></td>
<td>5  41.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3  25.0%</td>
<td></td>
</tr>
<tr>
<td>4.5 - 6</td>
<td>8  61.5%</td>
<td>13 52%</td>
</tr>
<tr>
<td></td>
<td>3  23.1%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1  7.7%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11 44.0%</td>
<td>25 100%</td>
</tr>
<tr>
<td></td>
<td>8  32.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4  16.0%</td>
<td></td>
</tr>
<tr>
<td>Chi-Square Tests = .156</td>
<td>P-Value = .161</td>
<td></td>
</tr>
</tbody>
</table>

4.4.4 The Hindfoot Equinus:

With Measuring the tibio-calcaneal angle on the DP view, with the normal value between 60 – 90 degree and any increase in the angle more than 90 degree would be considered hindfoot equinus, with farther classification to mild moderate and severe accordingly. The data obtained showed no statistical significance (P-value > 0.05).

Table 4.6: A table showing the correlation between the Pirani clinical score value and the degree of the lateral Tibio-calcaneal angle.

<table>
<thead>
<tr>
<th>Pirani score</th>
<th>Talocalcaneal angle DP</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>normal 60 – 90</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mild 90 - 110</td>
<td></td>
</tr>
<tr>
<td></td>
<td>moderate 110 - 130</td>
<td></td>
</tr>
<tr>
<td></td>
<td>severe more than 130</td>
<td></td>
</tr>
<tr>
<td>0 - 4.5</td>
<td>3  25.0%</td>
<td>12 48%</td>
</tr>
<tr>
<td></td>
<td>3  25.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1  8.3%</td>
<td></td>
</tr>
<tr>
<td>4.5 - 6</td>
<td>0  0.0%</td>
<td>13 52%</td>
</tr>
<tr>
<td></td>
<td>3  23.1%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4  30.8%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3  12.0%</td>
<td>25 100%</td>
</tr>
<tr>
<td></td>
<td>6  24.0%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5  20.0%</td>
<td></td>
</tr>
<tr>
<td>Chi-Square Tests = .105</td>
<td>P-Value = .206</td>
<td></td>
</tr>
</tbody>
</table>

25
CHAPTER FIVE

DISCUSSION

This is a hospital based prospective study conducted to describe the anatomical bony arrangement of the CTEV deformity by measuring four angles each one referring to a component in the deformity and to correlate these finding with the clinical scoring system subjectively used to describe the severity of this deformity.

The samples collected from three different centres treating this condition in Sudan which were Gezira traumatology and orthopaedic centre in wad-medani and Omdurman teaching hospital and Soba teaching hospital-pediatric orthopaedic department in Khartoum. These centres were reliable sampling area because they receive cases from most Sudan.

Regarding the gender the study displayed a similar distribution to what mentioned in the literature with a male predominance of 62.50% and females were 37.50 %, the male to female ratio obtained was 1.6:1.

The age distribution was categorized into three groups: with those presenting before the 6 month were (70.59%) this majority can be explained because its congenital deformity and age of presentation can affect the management options “Göksan, S.B., et al 2006”. the rest were 11.76% for those between 6 month to 1 year and (17.65%) of the patients presenting later than one year which is the walking age for the child and those were considered a neglected cases, and above this makes the surgery the likely method of treatment “Lourenço, A. F 2007”.

Regarding the laterality of the condition and the commonly affected side, the right side was obtained in 40% and the left side affected alone only in 6.6% of the cases, the rest were bilaterally affected with 53.33%. So this study concluded a similar result to what is mentioned in the literature that half of the cases of CTEV are bilaterally affected. “Zionts LE 2017” “Mkandawire, N.C.2004”.

The aim of this study was to find a correlation between the clinical examination of the condition using the pirani scoring system and the underlying bony anatomy of the condition. These relation was obtained by categorising the TPS into two groups using the 4.5 as cut-off point above and below which the severity and management option differ. “Badmus H 2017” “Dyer and Davis 2006” “Scher DM et al 2004”.

Using four bony measurements to assess the deformity, two angles showed significant correlation while the other two were not.

The first measure was the Talo-1st metatarsal angle on the DP view to describe the forefoot adduction, From the 25 feet examined there were 12 considered having low severity
score (TPS < 4.5) and 13 feet were having a high severity score (TPS > 4.5). From those having a high clinical score 92.3% (12 feet) were having a severe angle measure of more than 60 degree. And those with the low TPS of less than 4.5 were having a random distribution to the angle ranging from 25% having a normal angle, 33.3% with mild (20 – 40 degree), 16.7% were having a moderate (40 – 60 degree). And 25% having a severe form. This was found a statistically significance with a P. value of .001 which describe relation between the Pirani clinical severity score and the talo-1st metatarsal angle on the dorsoplantar view, although deferent method were used, the result were similar to the study of Laaveg SJ, Ponseti IV.1980 and Prasad P, 2009 who obtained similar results when correlated this angle with the clinical assessment of the foot.

Using the Talo-1st metatarsal angle on the lateral view to measure the midfoot cavus, the same distribution of the data mentioned above was obtained with 92.3% of those with a high TPS were having a severe form of more than 30 degree for this angle, the rest were distributed randomly within a low TPS with 16.7% having a normal angle, 50% having a moderate angle of 15 – 30 degree and 33.3% having a severe form. This was found statistically significant with P. value of .005. Which can state that there is relation between this angle and the clinical Pirani score. This is similar to what found in the literature “Banks AS et-al.2001; Herring JA. 2013”.

Although when measuring the Talocalcaneal angle on the DP view to obtain the hindfoot varus. This was found statistically insignificant with P. value of .161. With 61.5% of patient with a high TPS were having a normal angle and random distribution among those having a low TPS. So this can either mean that this angle is not an accurate description of the hindfoot varus or there is no correlation between the hindfoot varus measurement and the clinical severity score. The later statement is in agreement with Laaveg and Ponseti 1980, Turco 1975, Ono and Hyashi 1974, Thompson et al 1982 who found no correlation between AP-TCA and functional rating. In contrast to this opinion Yamamoto and Furuyu 1988, Lau JH et al 1989 and Prasad P, 2009 found a statistically significant correlation of clinical scoring with AP-TCA.

When measuring the Tibio-calceanal angle on the lateral view for the hindfoot equinus. This angle was found statistically insignificant with a P. value of .206. With random distribution among those having a higher TPS, with those having a severe angle of more than 130 degree were 46.2%, those with a moderate angle were 30.8% and 27.3% are having a mild form, but no patient is having a normal angle. In contrast to those having low TPS only 23.1% having a normal angle and the majority with 41.7% having a severe angle. The random
distribution and those with low TPS having a higher angle can be explained by the fact that the
equinus is the last one to be corrected in the deformity by serial casting. This result
contradicting to what was reported in the literature as Handelsman JE, Soloman L 1973 and
Reimann I, Anderson HB.1974 agreed that this angle provided the most reliable angle index of
correction.

This study provides a preliminary data, Although it have been reported in literature
that clubfoot is a common congenital malformation yet, the small sample size in this study
can be explained by the inability to collect the data from these centres simultaneously because
it is conducted by one researcher. Also most of cases encountered weekly were same patient
presenting for serial casting with one to two new case every 3 month and some of those were
discarded by the exclusion criteria. Hence a larger sample size is needed.
CHAPTER SIX
CONCLUSION AND RECOMMENDATION

6.1 Conclusion:

In conclusion, this study provides preliminary data which indicates the prevalence of the condition among males is twice that of females and half of those affected by the condition have it bilaterally. And in regards to age of the patient attending the clinic although it was reported that most of these cases presented late due to parent negligence and lack of knowledge that it’s a curable deformity those were only 17.65% of the data obtained.

The use of the Pirani clinical scoring system to describe the clubfoot deformity is correlated with the underlying bony anatomy of the deformity, although there is a wide range of angle to describe the component of the deformity the Talo-1st metatarsal angle on both DP and L view is a good measure to describe the forefoot adduction and midfoot cavus respectively. In contrast the talocalcaneal angle on the DP view is not a good measure for the hindfoot varus, this also applied to the tibio-calcaneal angle which was stated as the most reliable indicator for the correction, but alone can’t describe the severity of the deformity.

6.2 Recommendations:

The study recommends the use of the Pirani clinical score as a good and reliable indicator of the underlying bony arrangement with any increase of the score above 4.5 is an increase in the both DP and L Talo-1st metatarsal angle accordingly.

It also supports the use of initial radiography to address the deformity and follow-up of surgically treated clubfeet.

The use other angle to describe the hind-foot varus rather than the dorsoplantar Talo-calcaneal angle.

Researchers have to be aware not to depend on the degree of Tibio-calcaneal angle alone as measure for the correction.

It is advised to use the initial DP and L foot x-ray with the Pirani clinical score to follow the treatment process of the condition.

Further study has to combine both the clinical assessment and the x-ray measurement in one score to classify the severity of the deformity and the management options accordingly.
REFERENCES


Inclan. Anomalous tendon insertions theory, though other studies have not supported this; the distorted anatomy can make it appear that tendon insertions are anomalous. *J Bone Joint Surg Am.* 1958. 40:159


Minoo Patel, John Herzenberg, Clubfoot
https://emedicine.medscape.com/article/1237077-overview#a12 Apr 17, 2017


Pirani S, Hodges D & Sekeramayi F A reliable and valid method of assessing the amount of deformity in the congenital clubfoot deformity (2003)


Vinod K Panchbhavi, MD. Foot Bone Anatomy


ANNEXES

8.1 Clubfoot:

Annex 1: CTEV  http://pedsinreview.aappublications.org/content/30/8/287

Annex 2: normal and abnormal talocalcaneal angle DP view The Beauty of Bones - WordPress.com
Annex 3: (a) Antero-posterior view of the foot showing the following angles: A talo-calcaneal angle, B talo-first metatarsal angle, C calcaneo-fifth metatarsal angle. (b) Lateral view of the foot showing the following angles: D tibio-talar angle, E tibio-calcaneal angle, F talo-calcaneal angle, G first-fifth metatarsal angle, H calcaneo-fifth metatarsal angle “Prasad P et al”

Annex 4: Pirani Scoring (Global Clubfoot Initiative)
# 8.2 Foot Limb Development

**Table 8.1:** Different structures of the lower extremities age of appearance

<table>
<thead>
<tr>
<th>Structure</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventrolateral surface swelling</td>
<td>3-week-old embryo</td>
</tr>
<tr>
<td>A true limb bud</td>
<td>4 postovulatory week (3-6 mm crown-to-rump length). located opposite the 5 lumbar and first sacral somites extends</td>
</tr>
<tr>
<td>Sacral somites extends toward the sacral myotomes and</td>
<td>The 6-9 mm stage</td>
</tr>
<tr>
<td>A transient apical epidermal ridge which is critical to maintaining limb outgrowth appears.</td>
<td></td>
</tr>
<tr>
<td>The thigh, leg, and foot appear</td>
<td>End of the 4th (8-11 mm stage).</td>
</tr>
<tr>
<td>A flat, rounded foot disk develops</td>
<td>Within the fifth week (11-13 mm embryo)</td>
</tr>
<tr>
<td>Mesenchymal condensation [skeleton-genesis]</td>
<td>fifth week (11-13 mm embryo)</td>
</tr>
<tr>
<td>Foot growth continues, 5 rays evolve into a more fanlike structure.</td>
<td>14 mm embryo</td>
</tr>
<tr>
<td>Ossification</td>
<td>continues postnatally, through puberty until mid-20s</td>
</tr>
<tr>
<td>Rotation</td>
<td>continues in the sixth week (14-16 mm)</td>
</tr>
<tr>
<td>Notching of the footplate</td>
<td>Continues such that toes are clearly apparent in the 21-23 mm embryo.</td>
</tr>
<tr>
<td>Both feet are nearly sagittal in orientation</td>
<td>In the seventh week (22-24 mm)</td>
</tr>
<tr>
<td>Vacuolar invasion of the talus</td>
<td>at 43 mm</td>
</tr>
<tr>
<td>Chondrification reached the distal phalanxes</td>
<td>at (28 mm)</td>
</tr>
<tr>
<td>Chondrification reached the malleoli</td>
<td>at (30 mm).</td>
</tr>
<tr>
<td>Vacuolar invasion of the talus</td>
<td>at 43 mm</td>
</tr>
<tr>
<td>Distal phalanges and metatarsal shafts</td>
<td>(week 9-10)</td>
</tr>
<tr>
<td>The talus ossifies, and the cuboid may be ossified at birth.</td>
<td>at 8 months</td>
</tr>
<tr>
<td>The cuboid may be ossified</td>
<td>At birth.</td>
</tr>
</tbody>
</table>
Annex 5- Hand, lower extremities embryology. (Adapted from Essentials of Human Embryology Larson Chapter 11)


8.3 Anatomy of the Foot:


Annex 10: Medial surface of the talus bone.
Annex 11: Lateral surface of the talus bone.

Annex 12: Superior surface of the calcaneus bone.
Annex 13: Anterior surface of the calcaneus bone.

Annex 14: Medial surface of the calcaneus bone.
Annex 15: Superior view of the talus and navicular bones.

Annex 16: Dorsal surface of the navicular bone.

*Navicular bone, articulations*

Image scanner:

Annex 17: Digital X-Ray machine AGFA
8.4 Questionnaire

- Personal data:
  - Name:
  - Age:
  - Residence:
  - Visit:
  - The hospital:

- Past medical history:
  - Age at delivery:
    - Preterm
    - Term
    - Post-term
  - The delivery:
    - Normal
    - C\S
  - Complications:
    - No
    - Yes, what …………………………
  - Other Congenital deformity:
    - No
    - Yes, what …………………………

- Family history:
  - Is there any similar condition??
    - Yes
    - No
  - Is there any congenital anomaly in the family??
    - Yes
    - No
  - Twins:
    - Yes
    - No

- The deformity:
  - Site:
    - Unilateral
      - Right
      - left
    - Bilateral
  - The Pirani clinical score:
    - (Rt) FOOT
      - The equinus 1 0.5 0
      - The empty heel 1 0.5 0
      - The post. Creases 1 0.5 0
      - The medial Creases 1 0.5 0
      - The lateral curve 1 0.5 0
      - The talas head 1 0.5 0
    - Total: ……………… ………………
- The x-ray angles:
  - DP talo-first metatarsal angle (ADUCTION)
    - 0-20 normal
    - 20-40 mild
    - 40-60 Moderate
    - >60 severe
  - Lateral Talo-first metatarsal (Meary’s angle) L. (CAVUS)
    - 0-4 normal
    - 4-15 mild
    - 15-30 moderate
    - >30 severe
  - Lateral Tibio-talar angle (EGUINUS)
    - 60 – 90 normal
    - 90 – 110 mild
    - 110 -130 moderate
    - >130 severe
  - The talo-calcaneal DP. (VARUS)
    - 25 - 40 normal
    - 20 - 25 Mild
    - 15 - 20 moderate
    - <15 severe