

Metarsus adductus in infants and toddlers: a literature review of clinical measurement tools

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ABSTRACT

Background: Metatarsus adductus (MA) is a common lower limb torsional abnormality that affects 1/1000 births and is one of the reasons for in-toeing in children. This condition has a good prognosis as it commonly spontaneously recovers around the school-age years, with 10-15% of cases persisting. At present there is a lack of agreement in terms of definition, standard approach of measurement and documentation criteria and robust evidence for the validity of intra- or inter-examiner reliability. This creates a barrier in monitoring and referring cases appropriately between clinicians as well as providing prognosis and reassuring parents. The aim of this study was to align the clinical needs of documentation and observation in these common clinical cases. **Method:** Literature search of the Cochrane library, Pubmed and ScienceDirect was undertaken. Keywords used: 'MA', 'Intoeing', 'measurements/classification', in English language, 1-3 years, excluding congenital abnormalities and neurological causes. Articles identified were screened for relevance and references were further assessed. **Results:** 173 articles were identified of which 18 fulfilled the requirements. Out of the 8 relevant articles, only 3 were fully compatible with the age in question. Techniques to measure metatarsus adductus included the heel bisector method, photocopies, ultrasound, footprints, dynamic foot pressure and radiographs. Radiographs are considered inappropriate for the toddler age group. Lack of robust evidence was an issue with identifying inter- and intra-rater reliability with both radiographic and non-radiographic findings, especially in relation to the pediatric population. **Conclusion:** Clinicians can use history and physical examination to rule out 'red flag' findings and other pathologies and monitor the progress using non radiographic methods. Given the lack of skeletal maturity, as well as the radiosensitivity in the toddler age group, x-rays should be avoided unless indicated for intervention.

Keywords: Pediatrics, metatarsus adductus, intoeing, toddlers/infants, classification, measuring tools, inter/intra reliability

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Introduction

Metatarsus adductus (MA) is a common lower limb torsional abnormality that affects 1/1000 births and is one of the reasons for the common presentation of in-toeing in children. This condition has a fairly good prognosis as it spontaneously recovers around the school-age years, with 10-15% of cases persisting.¹ However, the clinician must be able to determine when the condition is benign and when further investigation is required. This is a grey area where reviewing the literature may have value. It is thought that untreated MA as a child may be implicated in adult hallux valgus, hammer toes, fifth metatarsal stress fractures, difficulty in shoe fitting and can contribute to increased trips and falls later in life.

The term metatarsus adductus was first used by Carmer in 1909, and since then the term has been used to describe a 'uniplanar transverse deformity of the metatarsal bone at the tarsometatarsal joint (Lisfranc joint).² Additional observational findings associated with the presence of metatarsus adductus is the prominent fibula due to the

convexity of the lateral border of the foot.³ In spite of the term being used in the last 111 years and this finding being one of the most common congenital lower limb deformities in infants, the etiology and epidemiology of this condition are still unclear.⁴ A number of theories suggest the primary cause of MA is due to intrauterine constraint,⁵ oligohydramnios (a disorder of amniotic fluid resulting in decreased amniotic fluid volume for gestational age) and or poor muscle activation. None of these theories have been proven.⁵

At birth the walls of metatarsal shafts along with calcaneus, talus and occasionally cuboid are the only points that can be used as landmarks⁶ in pediatric radiographs, as the other bones have not yet ossified.⁷

Therefore, the questions are, first, what are the currently available tools used to identify/quantify the presence of MA in infants and children? How accurate are they? Second, is there a legitimate challenge to the hypothesis that

radiographic measurements prove to be more accurate than non-radiographic measuring techniques in the pediatric population?

Tests for the condition are important as they drive the need for treatment and may be implicated if unnecessary treatment is initiated.

Method

For the purpose of this study, toddler age was based on the Center for Disease Control and Prevention 2020 definition which has determined the toddler age as 1-3 years. Keywords used to explore the literature included: 'Metatarsus adductus', 'in-toeing', 'toddlers/infants', 'Classification', 'Measuring tools', 'inter/intra reliability'. The inclusion criteria defined included literature in English language, with no time restriction in years, healthy 1-3 year olds, in developed countries. Exclusion criteria eliminated neurological conditions (i.e. spasticity, cerebral palsy), other causes of in-toeing (tibial torsion and hip anteversion) as well as congenital abnormalities such as clubfoot, syndactyly, agenesis of foot bones, metatarsus varus.

Literature search commenced by examining The Cochrane Library for systematic reviews and trials around identification/measuring and quantification of MA and in-toeing in infant and children. Five trials were identified with 0 relevance. A collective of 173 articles were initially identified via Pubmed using both MeSH and advanced search terms. Of these, 11 relevant articles were identified and used in this study. A further 7 studies were identified by assessment of their reference list. A total of 18 articles were sourced and a total of eight proved to be relevant.

Results

The diagnostic process to identify MA is primarily conducted by observation and bedside physical examination.⁸ The two most common types of assessment tools are radiographic and non-radiographic methods. Some of the more commonly used classification tools for MA are Bleck's heel bisector method,² Foot Progression Angle, 'V' finger classification test and Ganley and Ganley MA flexibility test.⁹ The radiographic methods are x-rays, foot scans and ultrasonography.¹⁰ The simplest tool is to place the child in standing position onto a copy machine and push "print."

The 'V' finger test is a simple bedside examination tool where the heel of the child is placed between the examiner's index and 3rd finger. This allows observation of forefoot deviation and alerts the clinician to thoroughly examine for metatarsus adductus.³ The Ganley and Ganley MA flexibility test is also a simple bedside exam tool that can follow the 'V finger test'. This test requires the examiner to manually correct the deformity using very low force to encourage the in-toeing deformity to be eliminated.¹¹ If the

foot is flexible, the clinician is able to assess that this is a moderate and non-progressive case of MA.

Berg's classification of MA appears to be the most commonly referenced type of classification tool. This classification combines findings from Bleck's 'heel bisector method' and serves two purposes: firstly to differentiate severity of each case into mild, moderate and severe cases and also to identify flexible, partially flexible and fixed MA cases.^{11,12} In the normal foot, the heel bisector line starts at the calcaneus and should cross between the 2nd and the 3rd toes, whereas in severe cases, this line crosses between 4th and 5th toes.¹³ However, this classification has been modified by different authors who have tried to improve the reliability of the test. 'Lateral border heel line' is one of the adjunct suggestions proposed by Karami et al. (2017) in an attempt to challenge and improve the validity of this tool.¹⁴ Karami compared the MA severity index and Berg's classification and found a good rho (coefficient) between the two tests; hence, the two variables are similar and can be used interchangeably.¹⁴ Despite the novel approach, not much was done in terms of assessing the intra- and inter-examiner reliability of this tool. This should be taken into consideration when evaluating the results.

Technology affords us the identification/quantification of MA with the radiographic examination. Using radiographic measurements, the clinician needs to anticipate if the risk outweighs the benefit in each case, given that toddlers are more radiosensitive than adults. The FDA's Center for Devices and Radiological Health (CDRH) states that despite the use of minimal dosage in children's radiographs,^{5,15} these should be prescribed with caution and used only in cases that are essential for diagnosis or preoperative determination.

Numerous types of measurements are available in the radiographic field to assess the presence of MA.¹⁶ However, the validity and reliability of most of these measurements is currently being questioned as the age group in question has insufficient ossification of important foot landmarks due to their skeletal maturity.⁷ A number of articles commented on the validity of what is considered the traditional angle and most commonly used radiographic angles.⁶ These included: Kite's angle (talo-first metatarsal angle), Calcaneal — 5th metatarsal angle, calcaneus and 2nd metatarsal angle as traditional measurements for MA evaluation. Engel's angle (middle cuneiform and 2nd metatarsal angle), heel bisector variability and talus/1st metatarsal angles have more recently been advocated.⁹

Within the field of imagery studies, 'foot scans' are also advocated. The use of 'static weight bearing foot scan' appears to be the method most commonly used within this category to assess the pediatric MA. This position allows

the foot to get into the plantigrade position and reduces the flexibility component allowing a true measurement of the resting weight bearing position.¹⁴ However, the limited number of studies describing this method does not allow for much comparison of technique nor examination of limitations and human error involved in these tests. Positioning and supporting a dependent child with standing can easily introduce some variables that can skew the results. Human errors in positioning and bias in holding are some potential issues.

A more recent technique that has attracted the interest of researchers is the use of ultrasound techniques as it allows the visualization of cartilaginous regions in the tarsal bones.¹⁴ The dynamic component of ultrasound means that it can be combined with the standard bedside examinations such as the Ganley and Ganley flexibility test. This allows observing the ability of the foot to correct along with assessing the integrity of all the cartilaginous structures.¹⁰

In summary, there is a lack of agreement in terms of definition, standard approach of measurement and robust evidence for validity or intra- and inter-rated reliability.^{6,9,14} Inter-rater reliability refers to degree of agreement among raters. Intra-rater reliability refers to the ability of the same examiner to reproduce the results in different cases. No studies have been identified where intra/inter-rater reliability was examined in the pediatric population. No clear gender comparisons were made in the samples tested in the studies.

Discussion

The goal of this paper was to determine the most credible clinical/scientific methods to diagnose metatarsus adductus and predict its prognosis in the infant and toddler population. None of the studies found were devised to do more than describe the methods used to determine the degree of metatarsus adductus so the predictability question was not answered.

If metatarsus adductus persists beyond the preschool age, radiographic findings can provide a more robust answer as to the reason and inform both the clinician who can recommend interventions and give the parents a prognosis given the high inter- and intra-rater reliability in the older age groups. In the infant/toddler group, an observational approach i.e., Berg's classification¹¹ can be the most appropriate starting point. Despite this, the findings provide no answers to whether spontaneous recovery will be achieved. Checking flexibility of the foot can have clinical utility in this regard. Further, the clinician can combine the visual observation of the heel bisector to the case history and growth chart of each child and make appropriate recommendations. In all cases of evidence-based practice, it is important to examine the available literature, use

clinician's expertise and patient's or parent's needs and preferences. MA can be documented and observed in this way.

A lack of uniform evaluation was observed in the research literature. In quantification tools, radiographs in weight bearing were most commonly done in the older age group. Foot prints and visual bisectors were also used as quantification tools. However, among non-invasive methods, The Berg classification is one of the more commonly used non-invasive identification/quantification techniques in studies. Foot scans and ultrasonography were the alternative non-invasive methods and have been observed more commonly the last 5 years.¹⁴ However paucity of evidence for intra- and inter-reliability is observed in the research creating a discrepancy in comparing results and drawing conclusions at this point in time.

Appreciating the lack of ossification in foot structures of this population and utilising the FDA advice on radiosensitivity, radiographic interventions must be avoided at this age group unless indicated by history.^{15,16}

In summary, there is a lack of agreement in terms of definition, standard approach of measurement and robust evidence for the validity of intra- and inter-rated reliability. More research is required to meet these milestones.

There are both non-invasive measuring tools and invasive (radiographic) tools to evaluate a toddler for MA. There is insufficient robust evidence for the quality, reliability and validity for any of the methods. Because parents commonly consult chiropractors for the condition of MA in their infant or toddler, it is essential that each chiropractor determine the best method to determine degree of the problem along with prognosis. Further, an understanding of the methods will potentially improve interprofessional communication and monitoring.

The articles identified in this study are few and the age category proves very difficult to identify sufficient research for consideration.

Conclusion

A universally used/accepted tool to assess the MA in toddlers could not only improve inter-professional management and intervention but also be able to reassure parents and manage their expectations.

Considering best evidence, the clinician is left to determine what works best in their own clinical setting. Certainly, chiropractors are able to determine the flexibility of the deformity, which indicates it is a short-term rather than long-term issue. More meaningful conclusions can be made if longitudinal cross-sectional studies are available in the

future for assessing progression of metatarsus adductus. Considering the 1/1000 prevalence of this finding, more work needs to be carried out to narrow the gap in identifying

for appropriate referral of the 10-15% cases with persistent MA. Based on these findings, there is a good indication that perhaps literature is not saturated in this domain.

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