Statistical Validation of the Grand Rapids Arch Collapse Classification

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Introduction/Purpose: Over the past decade, gastrocnemius equinus has become increasingly recognized as playing a critical role in multiple foot and ankle pathologies. Arch collapse has been previously described by multiple authors as commonly resulting from gastrocnemius equinus. The Grand Rapids Arch Collapse Classification system was devised in 2011 in order to assist physicians and patients to better understand the mechanism by which arch collapse results, resulting from gastrocnemius equinus. Within this classification system, there are five types or stages described. These are based upon the part of the foot which is affected: gastrocnemius, forefoot, midfoot, hindfoot, ankle, respectively. The purpose of this study was to determine if this classification system is reproducible among physicians by measuring inter-rater and intra-rater reproducibility.

Methods: An a priori power analysis determined 50 clinical cases were were required to achieve significant reproducibility among our cohort. From the extensive clinic EMR, a senior author identified a stratified selection of 50 (10 per type) random patients with foot pain and suitable radiographic films from each Grand Rapids classification type. De-identified pre-treatment radiographs and clinical synopses of corresponding patients were provided to ensure clarity, with x-rays, blinded data, and the complete spectrum of cases. All subject x-rays included weight bearing AP, lateral foot and AP, and lateral ankle views. Thirty-three physicians of differing levels of training were sent a test using Qualtrics software with a description of the classification scheme and the 50 cases in a randomized order and analyzed for inter-rater reproducibility. They were then asked to take the same test 8 weeks later to analyze for intra-rater agreement.

Results: Of the 33 physicians who received the test, 26 completed the first round (16 attendings, four foot and ankle fellows, and six residents). Kappa coefficient analysis was performed to determine the level of agreement among all subjects. There was substantial agreement among raters in all five types and overall. Kappa scores for each were 0.7164, 0.6510, 0.7219, 0.7013, 0.6291, respectively. The combined Kappa score for all five types was 0.6839, which demonstrates a marked level of agreement. After eight weeks, 13 of the 26 subjects repeated the study which allowed for a calculation of intra-rater reproducibility. A Kappa analysis was once again performed for the 13 subjects that produced a substantial level of agreement with a value of 0.744 for intra-rater reproducibility.

Conclusion: The Grand Rapids Arch Collapse Classification system was designed to improve patient satisfaction and provide a mechanism for physicians to easily describe the effects arch collapse. This usefulness of this system is wholly reliant on the repeatability among clinicians. This study has demonstrated that the classification system has substantial reproducibility among physicians.
## Grand Rapids Arch Collapse Classification (GRACC)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Affected Part of the Foot</th>
<th>Presenting Pathology</th>
<th>Biomechanics</th>
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| **GR Type 1**  | Gastrocnemius (Pre-collapse, no foot deformity) | - Gastrocnemius equinus  
- Plantar fasciitis  
- Metatarsalgia  
- Achilles tendon pain | - Weakened support of the arches  
- Tensile failure of posterior and plantar soft tissues |
| **GR Type 2**  | Forefoot | - Hypermobile first ray  
- Hallux valgus  
- Lesser toe deformity  
- Metatarsalgia  
- Metatarsal stress fracture | - Medial column incompetence with weightbearing transfer to lesser rays |
| **GR Type 3**  | Midfoot | - Midfoot arthritis:  
- 2nd and 3rd TMT Arthritis  
- Medial navicular arthritis | - Transverse arch collapse |
| **GR Type 4**  | Hindfoot | - Hindfoot valgus  
- Pertalar subluxation  
- PTT pathology  
- Lateral hindfoot/subtalar arthritis  
- Sinus tarsi impingement | - Medial arch collapse with spring ligament attenuation and hindfoot valgus |
| **GR Type 5**  | Ankle | - Valgus ankle arthritis | - Deltoid ligament attenuation |