

The biomechanical consequences of hallux rigidus and treatment on gait and clinical functioning

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CHAPTER 8

IMPACT PARAGRAPH

AIMS, RESULTS AND CONCLUSIONS OF THE STUDIES

Hallux rigidus (HR) is a disease in which the joint of the great toe (hallux) is painful and stiff due to osteoarthritis. Hallux rigidus is the most prevalent form of osteoarthritis in the foot and the occurrence of HR is expected to increase due to aging of the population. The hallux is of major importance in human walking. Diseases of the hallux such as HR are known to have a severe impact on walking and other daily activities, thereby negatively influencing the experienced quality of life. In which way HR influences gait and how the foot and lower limb compensate for this limited motion of the hallux is not known. Several surgical options are available to treat patients in whom conservative treatment failed. Although numerous studies have reported outcome after surgery, it is not known which intervention is superior in treating HR. This thesis describes several scientific studies to broaden our knowledge of gait characteristics and patient-reported outcome of patients with hallux rigidus (HR). In this chapter, these studies and their outcome are positioned in a broader context to transfer the scientific knowledge described into clinical practice and social impact.

A literature study was performed in **Chapter 2**, to examine whether a fusion of the great toe joint (or MTP1 arthrodesis) or replacement of the joint resulted in the best outcome. A MTP1 arthrodesis tend to be superior in reducing pain, improving clinical outcome and had less intervention-related complications and revisions illustrated by the results of this study.

In **Chapter 3**, gait and foot motion of patients with HR was investigated. As expected, diminished motion in the great toe was present. Increased motion of the forefoot was seen during push-off, to facilitate normal walking, while no difference in plantar loading was detected. Hence, this study illustrated that the foot itself has the capacity to compensate for the loss of motion in the hallux in patients with HR.

Whether this also influenced other joints in the lower limb was investigated in **Chapter 4**. Results revealed that patients with HR had a different gait pattern as compared to healthy subjects. Especially the ankle and pelvis are contributing to this altered gait pattern. Notably, there was a relation between the extent of gait deviation and the degree of well-being of patients, reported by themselves. The existence of such a relation between objective measured gait deviation and patient-reported outcome was not previously reported in HR patients.

The effect of fusion of the MTP1 joint, also known as an arthrodesis, on foot motion was studied in **Chapter 5**. Results illustrated that compensatory motion in the hindfoot

and forefoot enables the subject to walk efficiently, avoiding the rigid hallux while pushing-off. This resulted in a decreased pressure underneath the hallux and higher pressures under the outer plantar zones of the foot. This was the first study describing this compensatory mechanism after a MTP1 arthrodesis for HR.

Most studies reporting patient-reported outcome after HR have a follow-up period of months to a maximum of several years after surgery. In **Chapter 6**, the outcome after three surgical interventions (i.e. arthrodesis, cheilectomy and Keller's arthroplasty) for HR were evaluated more than 22 years after surgery. Results showed comparable pain scores, clinical outcomes and patient-reported outcomes among these three interventions. However, only subjects with MTP1 arthrodesis showed a further decrease in experienced pain and improvement in clinical outcome. Moreover, a clinically relevant better outcome was detected after arthrodesis as compared to cheilectomy and clinically relevant lower pain scores were seen after arthrodesis and Keller's arthroplasty as compared to cheilectomy. This led to the conclusion that based on these outcome measures, arthrodesis is the favorable intervention to treat patients with HR.

RELEVANCE

Aging is a major social challenge, due to increased risk of diseases which influence quality of life and health care costs. HR is an example of such a disease, since it is the most prevalent form of osteoarthritis in the foot and prevalence increases with aging.

Results of this thesis highly contribute to a further understanding of the effects of HR and treatment on walking, since no previous studies described the effects of HR on foot, ankle and lower limb motion in subjects with HR and after treatment with a MTP1 arthrodesis. This is the most performed intervention, because it tends to be the best choice based on patient-reported outcome and pain reducing effect. Previous studies in other diseases such as cerebral palsy showed that gait patterns can be used to predict outcome after surgery. Results in this thesis can form a starting point for future studies, to see whether this is also applicable for HR. Predicting outcome prior to surgery based on a person's walking pattern enables clinicians to give a better personalized advice for treatment. At patient-level, this will improve post-operative self-reliance, and will counteract inactivity with conjoined negative health effects. At health-care level, it will reduce hospital visits and revision surgeries needed. At sociopolitical-level these factors will contribute to keep the general health cost, which are already rising for years, affordable and improve 'healthy' aging.

ACTIVITIES AND PRODUCTS

The findings of this thesis have led to several activities in the field of expertise. The results of this thesis have been presented at various symposia and congresses, including the Northern Orthopaedic Federation Congress in 2016 (Linköping, Sweden), Nederlandse Orthopaedische Vereniging (NOV) congress in 2016 (Utrecht, The Netherlands), Gruijter symposium in 2016 (Alkmaar, The Netherlands), European Orthopedic Research Society (EORS) Annual Meeting in 2016 (Bologna, Italy) and 2017 (Munich, Germany). Furthermore, the findings have been translated into original manuscripts which were published in international scientific journals. Moreover, a summary of results were described in the most read medical journal in The Netherlands (Nederlands Tijdschrift voor Geneeskunde; NTVG 2018;162:D2547).

In addition, results have been presented at different meetings at Maastricht University, Maastricht University Medical Centre, Zuyderland Medical Centre (location Sittard), Amsterdam University Medical Centre (location Vrije Universiteit Amsterdam) and Noordwest Ziekenhuisgroep (location Alkmaar). In addition, results were presented at the Department of Mechanical and Manufacturing Engineering, Aalborg University, during a short internship to enlarge knowledge of foot modelling. Furthermore, a collaboration between the Department of Orthopedic Surgery of the Maastricht University Medical Centre, Department of Orthopedic Surgery of the Noordwest Ziekenhuisgroep (Alkmaar) and Department of Rehabilitation Medicine of Amsterdam UMC was set-up during this PhD-trajectory. This collaboration resulted in a research period in the Amsterdam UMC, to gain more expertise in gait analysis. In addition, results presented in this thesis were used for educational purposes for student at Maastricht University. At last, this thesis may inspire future research in understanding gait in patients with HR and determining methods to improve treatment of subjects with HR.

TARGET GROUPS

Health care professionals

The results of this thesis are primarily important for health care providers, such as orthopedic surgeons, general practitioners and physiotherapists. Orthopedic surgeons can use results described in this thesis in deciding which intervention to perform. For example, it is reasonable to assume that subjects with osteoarthritic changes in the forefoot and hindfoot will benefit less from and should not be treated with a MTP1 arthrodesis, since these are the major compensatory segments after surgery. General

practitioners and physiotherapists can use the information from this thesis to give a thorough explanation to patients, when they visit them and report complaints in adjacent, compensating joints. Furthermore, results obtained in this thesis can be used for the development of a uniform guideline for clinicians who will treat patients with HR at different stages of disease. At the moment, such guideline is not available for foot and ankle problems, while it is available for wrist and hand problems (i.e. NHG-standaard M91; Hand- en polsklachten – February 2021).

Patients with Hallux Rigidus

This thesis shed light on gait characteristics and compensatory joint motion in HR subjects. On the long term, patients may benefit from a better understanding of gait impairments in HR. If future studies are able to develop a method in which personalized treatment is optimized based on evaluation of gait and subsequently guidelines are developed, patients will definitely benefit.