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Wear Prediction on Total Ankle Replacement

Effect of Design Parameters

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ISSN 2191-530X ISSN 2191-5318 (electronic)
SpringerBriefs in Applied Sciences and Technology
ISSN 2191-5342 ISSN 2191-5350 (electronic)
SpringerBriefs in Computational Mechanics
ISBN 978-3-319-21722-2 ISBN 978-3-319-21723-9 (eBook)
DOI 10.1007/978-3-319-21723-9

Library of Congress Control Number: 2015944744

Springer Cham Heidelberg New York Dordrecht London
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Printed on acid-free paper

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(www.springer.com)

This book is dedicated to my parents, who taught me to strive to achieve success because success does not come easily and made the experience of facing challenges as a supply meaningful to benefit in the future. It is also dedicated to my wife who always stands beside me to inspire and support to create the best in any field.

Preface

Loosening of the bearing component of total ankle replacement (TAR) became the main cause to implant failure. The ankle joint is the lowest joint in the human body. It has a complex mechanism with build-up of four bones, namely tibia, fibula, talus, and calcaneous. The ligamentous structure on the ankle joint is the most important part in providing stability while performing any physical activity. The bone ends of the joints in human bodies are covered by cartilage that a flexible connective tissue allows the bones to move effectively and smoothly without pain. The cartilage in the lower limb joints is used to carry body weight and allows for shock absorption. However, deterioration or wearing away of joint cartilage causes arthritis to occur. Arthritis is the main issue that brings an ankle joint to have an operative management. Total ankle replacement (TAR) is consistently referred to treat the disorder. The wear of polyethylene produced wear particles induced osteolysis which is limiting longevity of TAR. The wears of polyethylene leading to osteolysis in the long-term period due to the development of wear particles which cause bone losses surrounding implant lead to instability and subsequently loosen the implant components.

Acknowledgments

This project was sponsored by Universiti Teknologi Malaysia (UTM) through Grantt University Project (GUP) Q.J130000.2509.06H10. The authors would also like to thanks to Ministry of Higher Education Malaysia (KPM) for financial support.

Contents

1	Introduction	1
1.1	Ankle Joint Anatomy	2
1.1.1	Ankle Biomechanics	4
1.1.2	Loading on the Ankle	5
1.1.3	Kinematics of the Ankle	7
1.2	Ankle Joint Problems that Lead to Surgical Treatment	7
1.3	Ankle Joint Treatment	9
1.3.1	Ankle Fusion	10
1.3.2	Total Ankle Replacement (TAR)	10
1.4	Total Ankle Replacement (TAR)	12
1.4.1	Agility TAR (DePuy, Warsaw, IN, USA)	12
1.4.2	Scandinavian Total Ankle Replacement (STAR) (Waldmar Link, Hamburg, Germany)	13
1.4.3	Buechel-Pappas (BP) TAR	14
1.4.4	Bologna, Oxford Total Ankle Replacement (BOX)	15
1.5	Complications	15
	References	16
2	Contact Pressure of Total Ankle Replacement (TAR)	19
2.1	Geometric Model	19
2.2	Finite Element Analysis	20
2.2.1	Development of Finite Element Analysis of Gait Cycle	21
2.3	Contact Analysis	25
2.3.1	Contact Pressure of Total Ankle Replacement (TAR)	26
2.4	Sliding Distance	27
2.5	Validity of Contact Analysis	28
2.5.1	Mesh Sensitivity Test	29
2.5.2	Contact Analysis	30
	References	31

3	Wear of Total Ankle Replacement (TAR)	33
3.1	Fundamental of Wear Modelling	33
3.1.1	Wear of Total Ankle Replacement (TAR)	34
3.2	Wear Model of Total Ankle Replacement (TAR)	35
3.3	Update Contact Geometry of Total Ankle Replacement (TAR)	36
3.4	Wear Sensitivity Study	38
	References	40
4	Effect of Design Parameter Towards Wear Generation	43
4.1	Parametric Study	43
4.1.1	Thickness of Meniscal Bearing	43
4.1.2	Radial Contact of Meniscal Bearing	47
	References	52
5	Conclusion	55

Abstract

Computational wear simulation has been widely used to predict wear generated on hip and knee implants, but studies related to wear analysis on the ankle are limited. The purpose of this study is to develop finite element analysis on total ankle replacement (TAR) wear prediction. Three-dimensional (3D) models of a right ankle TAR have been created to represent Bologna-Oxford (BOX) TAR model. The model consists of three components; tibial, bearing and talar representing their physiological functions. The joint reaction force profile at ankle joint has applied 25 discrete instants during stance phase of a gait cycle. It is to determine the distribution of contact stress on meniscal bearing surfaces contact with talar component. The sliding distance was obtained from predominate motions of plantar/dorsi flexion. This study of wear simulation used 0.5 million cycles for update interval. The value of linear wear depth is 0.01614 mm per million cycles which is in agreement with other studies (0.0081–0.0339 mm per million cycles). The value of volumetric wear after five million cycles is 30.5 mm³ which is in agreement with other studies (16–66 mm³). It has been suggested that a change in implant dimensions may result in better implant lifespan. The wear process scenario simulated an ankle implant prosthetic design polyethylene with varying parameters which include thickness (4, 6, 8 and 12 mm) and radial curvature (16, 22, 30, 36 mm). Conclusion: Polyethylene wear is not influenced by the implant thickness but rather by the radial curvature of the implant.