



UNIVERSITI PUTRA MALAYSIA

***ASSOCIATION OF T2 MAPPING OF KNEE CARTILAGE WITH
AGE, GENDER & BMI AMONG YOUNG ADULTS ATTENDING PUSAT
PENGIMEJAN DIAGNOSTIK NUCKLEAR (PPDN),
UNIVERSITI PUTRA MALAYSIA***

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age, gender & BMI among young adults attending
Pusat Pengimejan Diagnostik Nuclear (PPDN),
Universiti Putra Malaysia**

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Master of Medicine (Radiology)

Association of T2 mapping of knee cartilage with age, gender & BMI among young adults attending Pusat Pengimejan Diagnostik Nuclear (PPDN), Universiti Putra Malaysia

By

SOO TZE HUI

May 2021

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According to World Health Organization, osteoarthritis (OA) is defined as a long-term chronic disease characterized by deterioration of joints cartilage as a sequelae of degenerative changes causing stiffness, pain and impaired mobility. The disease most commonly affects the joints in the knees, hands, feet, and spine and is relatively common in shoulder and hip joints. The prevalence of knee OA in Malaysia was estimated to be 10% to 20% of the elderly population and more common in adults aged 40 years and above.

Self-regeneration processes are only initiated when damage reaches the subchondral bones. Sudden and rapid applied excessive force would not allow for sufficient fluid to move through the matrix for shock absorption, thus allowing the stress to be applied fully on the macromolecules network causing micro tears and matrix injury. In severe cases, there might be segmental loss of cartilage. Macromolecules synthesized by chondrocytes are inadequate to fill the gaps caused by injuries. By times, OA start to

set in causing chronic pain and instability. MRI is the only imaging of choice that able to provide structural details as well as biochemical information about the articular cartilage. Moreover, it would be desirable for MRI to provide an evaluation of the underlying cartilage physiology including providing information about the status of prostaglandins (PGs) and collagen matrices. T2 mapping is straightforward to perform and is sensitive to changes in collagen as well as water content, but less sensitive in detection of early degeneration.

A retrospective and prospective cross sectional study using secondary and primary data to provide information on the value of T2 mapping of knee articular cartilage (medial and lateral compartment) in asymptomatic young adult and its association with gender, age and body mass index was carried out over a period of 2 years from December 2018 to December 2020. The data was then post processed with T2 mapping programming via Matlab R2019b version and further analysed with SPSS version 26.

Overall, we has shown that female has slightly higher mean T2 value (49.1731ms to 51.9192ms) as compared to male population (48.4147ms to 49.4647ms) out of 30 volunteers recruited. We concluded that as we age, the T2 value increases which signify the occurrence of OA has set in slowly. In our study, T2 value increases as BMI increase as well. With 3 independent variables tested, our result were consistent with previous studies even though there was no strong association ($p > 0.05$) obtained.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra
Malaysia sebagai memenuhi keperluan untuk Master Perubatan
(Radiologi)

**Korelasi antara nilai T2 mapping dengan usia, jantina & BMI di
kalangan orang dewasa muda yang menghadiri Pusat
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**Pengerusi: Professor Madya Dr. Hasyma binti Abu Hassan
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Menurut Pertubuhan Kesihatan Sedunia, osteoarthritis (OA) didefinisikan sebagai penyakit kronik yang dicirikan oleh kemerosotan tulang rawan sendi akibat degenerasi yang menyebabkan kekakuan, kesakitan dan gangguan mobiliti. Penyakit ini kerap menyerang sendi di lutut, tangan, kaki, tulang belakang dan agak biasa pada sendi bahu dan pinggul. Kelaziman OA lutut di Malaysia dianggarkan 10% hingga 20% daripada populasi warga tua dan lebih kerap berlaku pada orang dewasa yang berumur 40 tahun ke atas.

Proses regenerasi diri hanya dimulakan apabila kerosakan mencapai tulang subkondral. Kerosakan yang berlaku secara tiba-tiba tidak membenarkan cecair yang mencukupi bergerak melalui matriks untuk penyerapan kejutan, sehingga membiarkan tekanan digunakan sepenuhnya pada rangkaian makromolekul yang menyebabkan kecederaan matriks. Dalam kes yang teruk, mungkin terdapat kehilangan rawan. Makromolekul yang disintesis oleh chondrocytes tidak mencukupi untuk mengisi jurang yang disebabkan oleh kecederaan. Dari masa ke masa, OA mula menyebabkan kesakitan dan ketidakstabilan. MRI adalah satu-

satunya pengimejan pilihan yang dapat memberikan perincian struktur serta maklumat biokimia mengenai tulang rawan artikular. Lebih-lebih lagi, adalah wajar bagi MRI untuk memberikan penilaian terhadap fisiologi tulang rawan yang mendasari termasuk memberikan maklumat mengenai status PG dan matriks kolagen. Pemetaan T2 mudah dilakukan dan sensitif terhadap perubahan kolagen serta kandungan air, tetapi kurang sensitif dalam mengesan degenerasi awal.

Satu kajian retrospektif dan prospektif menggunakan data sekunder dan primer untuk memberikan maklumat mengenai nilai pemetaan T2 tulang rawan artikular lutut (medial dan lateral petak) pada orang dewasa muda tanpa gejala dan kaitannya dengan jantina, umur dan indeks jisim badan dilakukan selama jangka masa 2 tahun dari Disember 2018 hingga Disember 2020. Data tersebut kemudian diproses dengan pengaturcaraan pemetaan T2 melalui versi Matlab R2019b dan dianalisis lebih lanjut dengan SPSS versi 26.

Secara keseluruhan, kami telah menunjukkan bahawa wanita mempunyai mean nilai T2 yang lebih tinggi (49.1731ms hingga 51.9192ms) berbanding dengan populasi lelaki (48.4147ms hingga 49.4647ms) daripada 30 sukarelawan. Kesimpulannya, nilai T2 meningkat seiring dengan usianya yang menandakan kejadian OA. Dalam kajian kami, nilai T2 meningkat seiring peningkatan BMI juga. Dengan 3 independent variables yang diuji, keputusan kami adalah konsisten dengan kajian terdahulu walaupun tidak ada perkaitan yang kuat ($p > 0.05$).

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Last but not least, I am extremely grateful to my colleague and friends that support me endlessly until I manage to finish the research in a timely manner.

APPROVAL

I certify that a Thesis Examination Committee has met on 7th May 201 to conduct the final examination of Soo Tze Hui on her thesis entitled “Association of T2 mapping of knee cartilage with age, gender & BMI among young adults attending Pusat Pengimejan Diagnostik Nuclear (PPDN), Universiti Putra Malaysia” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Medicine (Radiology).

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LIST OF ABBREVIATIONS

ADC	Apparent diffusion coefficient
BMI	Body mass index
CT	Computed tomography
dGEMRIC	Delayed gadolinium enhanced MR imaging of cartilage
DWI	Diffusion weighted image
ECM	Extracellular matrix
FOV	Field of view
GRE	Gradient-recalled echo
ID	Identification number
JKEUPM	Medical Ethics Committee of Faculty of Medicines and Health Sciences, UPM
LL	Left knee lateral compartment
LM	Left knee medial compartment
MRI	Magnetic resonance imaging
ms	milliseconds
n	number
OA	Osteoarthritis
PDWI	Proton density weighted imaging
PG	Proteoglycans
PPDN	Pusat Pengimejan Diagnostik Nuklear
QQ plot	Quantile-normal plots
RL	Right knee lateral compartment
RM	Right knee medial compartment

SD	Standard deviation
SE	Spin-echo
SI	Signal intensity
TE	Echo time
TR	Repetition times
T1WI	T1 weighted image
T2WI	T2 weighted image
UPM	Universiti Putra Malaysia
WHO	World Health Organization



CHAPTER 1

INTRODUCTION

1.1 Background

According to World Health Organization, osteoarthritis (OA) is defined as a long-term chronic disease characterized by deterioration of joints cartilage as a sequelae of degenerative changes causing stiffness, pain and impaired mobility. The sites most commonly affected include knees, hands, feet, and spine as well as shoulder and hip joints. It is the fifth leading cause of disability in the entire population in high-income countries, and the ninth highest cause in low- and middle-income countries ⁽¹⁾. In Malaysia, the prevalence was around 10% to 20% in the elderly and more common in adults aged 40 years and above. The Community Oriented Program for the Control of Rheumatic Diseases (COPCORD) study conducted in Malaysia reported that 64.8% of joint complaints were attributed to knee and 23% of patients are over 55 years old, this statistic increased to 39% in those over 65 years old ⁽²⁾. It is a potential public health burden in the ageing population. Diagnosis of OA is frequently made by an overall clinical

impression. It was reported that plain radiograph and CT are insensitive in detecting early OA changes as once believed. With the advanced of technology, MRI has shown to be more superior in diagnosing OA, thus providing better clinical outcome and treatment choice. MRI enables to provide outstanding soft tissue contrast and is the best imaging of choice available for assessment of articular cartilage changes. Nonetheless, it is the safest modality owing to its non-ionizing radiation property.

Knee joint is the largest complex synovial hinge joint in our body that allow us to move in space and maintain posture. It is made up by distal femur, patella and proximal tibia which line by articular cartilage and synovium. Given the articular cartilage properties which has neither vessels, neural nor lymphatic, it also has very poor regenerative potential. Its main supply arises from simple diffusion of oxygen and nutrients from synovial fluid and basal subcondral bone (bone marrow). It serves as a shock absorber and protect the joint surfaces by distributing weight loads effectively. Two major components can be found inside the articular cartilage namely the extracellular matrix (ECM) and chondrocytes. ECM is

primarily made up of type II collagen, negatively charged proteoglycans (PGs), water and some minor components including some glycoproteins and non-collagenous proteins. Type II collagen are responsible for building the cartilaginous framework, whilst PGs contribute to hydrophilic behavior of articular cartilage. Chondrocytes maintain the articular cartilage homeostasis by secreting matrix constituents and matrix-degrading enzymes as well as having surface receptors for various cytokines and growth factors. Up to date, four different zones are identified within the articular cartilage which compose of superficial or tangential zone (10-20% of total cartilage thickness), middle or transitional zone (40-60% of total cartilage thickness), deep or radial zone (30- 40% of total cartilage thickness) and the calcified zone. Each of these zone comprises different composition of type II collagen, PGs and chondrocytes. Superficial zone has the largest amount of collagen and lowest PGs content. It protects the deeper layers from deformation and contribute to the most tensile properties. Middle zone has higher PGs content and thicker collagen fibrils. Deep zone has the highest PGs content among the rest, while calcified zone contains very few cells within.

Self-regeneration processes are only activated when damage reaches the subchondral bones. Unrestrained impact to the cartilage would cause insufficient fluid to move through the matrix for shock absorption, thus causing micro tears and matrix injury. In severe cases, there might be segmental loss of cartilage. By times, OA starts to set in causing chronic pain and instability ⁽³⁾. Diagnosis of OA is made by clinical evaluation and plain radiograph is used to support the diagnosis. Laboratory investigations may be done to exclude other inflammatory joint diseases. MRI is the only imaging of choice that is able to provide structural details as well as biochemical information about the articular cartilage. Moreover, it would be desirable for MRI to provide an evaluation of the underlying cartilage physiology including providing information about the status of PGs and collagen matrices. Conventional MRI sequences do not provide a comprehensive assessment of cartilage.

Normal cartilage comprised approximately 65% to 85% of water within the ECM, this characteristic made MRI imaging of water diffusion possible within the entire cartilage. T2 mapping is straightforward to perform and is sensitive to detect changes in

collagen as well as water content. Hence, measurement of T2 value with mapping alert us the early cartilage degeneration and might help the clinician to give an advice the patient in a proper manner.

1.2 Problem Statement

Diagnosis of early OA is made possible with the advanced of technology. Up to date, Malaysia still rely on patient sign and symptoms with conventional imaging in diagnosis OA. Patient always present late to medical practitioner when there is bothering symptoms that restrict their movement or disturb their daily life routine. At this point of time, OA is usually in advanced stages. Hence, early diagnosis of OA by measuring the T2 value of articular cartilage serve as an objective measurement which able to prevent all the undesired complications that might arise.

This retrospective and prospective cross sectional study using secondary and primary data is conducted to obtain value of T2 mapping of knee articular cartilage (medial and lateral compartment) in asymptomatic young adult in Pusat Pengimejan Diagnostik

Nuklear (PPDN), Universiti Putra Malaysia. Besides that, this study also conducted to investigate the association between T2 mapping value of both medial and lateral knee compartment with gender, age and body mass index.

1.3 Significance of Study

This retrospective and prospective cross sectional study using secondary and primary data is to provide information on the value of T2 mapping of knee articular cartilage (medial and lateral compartment) in asymptomatic young adult and its association with gender, age and body mass index which can serve as a quantitative measurement in diagnosing early osteoarthritis by using MRI.

1.4 Research Questions

In this study, we would like to investigate is there any association between T2 mapping value of knee articular cartilage (medial and lateral compartment) with gender, age and body mass index.

1.5 Objective

1.5.1 General objective

To obtain value of T2 mapping of knee articular cartilage (medial and lateral compartment) in asymptomatic young adult in Pusat Pengimejan Diagnostik Nuklear (PPDN), Universiti Putra Malaysia.

1.5.2 Specific objectives

- 1) To determine association between T2 mapping value of knee articular cartilage (medial and lateral compartment) with gender.
- 2) To determine association between T2 mapping value of knee articular cartilage (medial and lateral compartment) with age.
- 3) To determine association between T2 mapping value of knee articular cartilage (medial and lateral compartment) with body mass index.

1.6 Research Hypothesis

1.6.1 Hypothesis

There is no association between T2 mapping value of knee articular cartilage (medial and lateral compartment) with gender, age and body mass index.



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