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Riina Mattila

HIP AND KNEE REPLACEMENT IMPLANTS

– Information package for nurses / Hoitonetti

TURUN AMMATTIKORKEAKOULU
TURKU UNIVERSITY OF APPLIED SCIENCES

BACHELOR´S THESIS | ABSTRACT

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Sirpa Nikunen & Tiina Pelander

Riina Mattila

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Osteoarthritis is one of the most common joint diseases in the world. Osteoarthritis leads to the damage of the joint and adjacent structures. The disease causes serious joint pain and stiffness which may significantly affect moving, ability to function and the quality of life. The end-stage osteoarthritis of weight-bearing hip or knee joint is a disabling condition. There is no curative treatment for osteoarthritis but the symptoms of the disease can be usually effectively relieved. If the conservative treatments, such as guided exercises, weight loss and pain medications, which represent the basis of care, are not effective any more, a joint replacement can be considered. In joint replacement surgery, the damaged surfaces of the joint are replaced with artificial materials.

The hip and knee joint replacements are generally very effective for management of the symptoms of osteoarthritis. However, the optimal performance of a natural healthy joint cannot be achieved with an artificial man-made joint. On the other hand, the outcome of the joint replacement is usually significantly better than the pre-operative situation of the patient with osteoarthritis.

The task of this thesis was to do a literature review and collect a basic information package for nurses about joint replacements as a treatment option for end-stage osteoarthritis. The aim of the thesis was to share the knowledge based on resent research work about hip and knee replacement implant materials including the associated benefits and risk factors. In this thesis, the author briefly presents the anatomy and physiology of the hip and knee joints, the symptoms and risk factors related to osteoarthritis, the most common materials and methods used in the hip and knee joint replacements, and some factors affecting the lifespan of joint replacements. Finally, a few aspects which affect the patients' satisfaction after joint replacements are presented.

KEYWORDS:

Hip, joint replacement, knee, osteoarthritis

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Riina Mattila

LONKKA- JA POLVITEKONIVELET

- Tietopaketti sairaanhoitajille / Hoitonetti

Nivelrikko on yksi maailman yleisimmistä nivelsairauksista. Nivelrikko johtaa nivelen ja sitä ympäröivien rakenteiden vaurioitumiseen. Sairaus aiheuttaa potilaalle voimakasta nivelkipua ja jäykkyyttä, jotka saattavat vaikuttaa merkittävästi liikkumiseen, toimintakykyyn ja elämänlaatuun. Vaikea nivelrikko alaraajan painoa kantavissa lonkka- tai polvinivelissä on invalidisoiva. Nivelrikkoon ei ole olemassa parantavaa hoitoa, mutta sairauden oireita voidaan useimmiten tehokkaasti lievittää. Mikäli hoidon perustana olevat konservatiiviset hoitomuodot, kuten ohjatut liikeharjoittelut, painon pudotus ja kipulääkkeet, eivät enää auta, voidaan tekonivelleikkausta harkita. Tekonivelleikkauksessa nivelen vaurioituneet pinnat korvataan keinotekoisilla materiaaleilla.

Lonkan ja polven tekonivelleikkauksilla voidaan saavuttaa hyviä tuloksia nivelrikon oireiden hoidossa, mutta tekonivel ei koskaan vastaa terveen nivelen optimaalista toimintaa. Toisaalta tekonivelleikkauksella aikaansaatu lopputulos on yleensä merkittävästi parempi kuin nivelrikkopotilaan leikkausta edeltävä tilanne.

Tämän opinnäytetyön tehtävä oli tehdä kirjallisuuskatsaus ja koota sairaanhoitajille perustietopaketti tekonivelleikkauksista vaikean nivelrikon hoitokeinona. Opinnäytetyön tavoitteena oli jakaa tutkimukseen perustuvaa tietoa lonkka- ja polvitekonivelmateriaaleista sekä niihin liittyvistä eduista ja riskitekijöistä. Opinnäytetyössä esitellään lyhyesti lonkka- ja polvinivelten rakenne ja toiminta, nivelrikon oireet ja riskitekijät, yleisimmät lonkan ja polven tekonivelleikkauksissa käytetyt materiaalit ja menetelmät sekä joitakin tekonivelten elinkaareen liittyviä tekijöitä. Lopuksi käsitellään muutamia asioita, jotka vaikuttavat potilastyytyväisyyteen tekonivelleikkausten jälkeen.

ASIASANAT:

Lonkka, nivelrikko, polvi, tekonivelleikkaus

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LIST OF DEFINITIONS AND ABBREVIATIONS

Biomaterial	Material intended to interact with biological systems to evaluate, treat, augment or replace any tissue, organ of function of a body (Williams 1999).
Elastic modulus	Ratio of pressure (stress) applied to a material to the resistance (strain) produced by the material. An elastic modulus shows how much strain results from the applied stress. The stiffer a material is, the higher the elastic modulus value and the more difficult it is to deform. (Park & Lakes 2007, 43.)
Fatigue	When material is subjected to a constant or a repeated load below the fracture stress level, it can fail after some time (Park & Lakes 2007, 49).
Fracture toughness	Capacity of a material containing a crack to resist fracture (Park & Lakes 2007, 46-49).
Friction	Resistance to motion (Revell 2008, 33).
Hardness	Ability to resist scratching and indentation (Tailor *et al*. 2010).
MPa / GPa	Megapascal / gigapascal
Osteoconduction	Process of passively allowing bone to grow and remodel over a surface (Williams 1999).
Osteoinduction	Act or process of stimulating bone formation (Williams 1999).
Osseointegration	Direct structural and functional connection between living bone and the surface of an implant (Williams 1999).
Osteolysis	Active resorption of bone by osteoclasts (Williams 1999).
Osteosynthesis	Surgical procedure that stabilizes and joins the ends of fractured bones by mechanical devices such as metal plates, pins, rods, wires or screws (Williams 1999).
Stiffness	Force needed to achieve a certain deformation of a structure. (Baumgart 2000.)
Strain	The stretch ratio under applied load, i.e. deformed length per original length (Park & Lakes 2007, 43).
Stress	Applied force per cross-sectional area (Park & Lakes 2007, 42).
Wear	Progressive erosion of material from the surface of an implant occurring as a result of relative motion at the surface (Revell 2008, 34).

1 INTRODUCTION

Musculo-skeletal disorders are a major public health problem in Finland, they are the most common reason for doctor visits, and the second most common factor in disability pension decisions. In Finland, 32% of disability pension decisions were made based on musculo-skeletal disorders in 2010. (Finnish Centre for Pensions and The Social Insurance Institution of Finland 2011; Tules – kivuliasta ja kallista 2011.)

According to Health 2000 survey, 5.7% of Finnish men and 4.6% of women over the age of 30 years suffer from clinically diagnosed degenerative hip joint disease known as osteoarthritis which is the most common joint disorder in the world. The prevalence of knee osteoarthritis is 6.1% in men and 8.0% in women. Hip and knee osteoarthritis is uncommon among people under 45 years, but the incidence increases with age. 20% of both men and women at the age of 75 - 84 years suffer from hip osteoarthritis. Among the same age group 16% of men and 32% of women have knee osteoarthritis. (Kaila-Kangas 2007)

The persistent pain and functional capacity shortfall caused by osteoarthritis can often be eliminated or significantly reduced by a joint replacement surgery if other available treatments are not sufficient. In 2010, more than 18 000 hip and knee replacement surgeries were performed in Finland in order to maintain and restore the functional capacity of the population. (Perälä 2011; Tules – kivuliasta ja kallista 2011.)

The care of osteoarthritis is expensive and the aging population will increase the burden in the future. In Finland, the annual treatment and care expenses of osteoarthritis are in a milliard euro range. The average age of the patients who have gone through the joint replacement surgery is nowadays slightly under 70 years but the average age is decreasing. Developments in biomaterials and implant design technology have offered better joint replacement options also for younger and/or physically active patients suffering from osteoarthritis. (Tules – kivuliasta ja kallista 2011; Vainikainen 2010, 10-12.)

The task of this thesis was to do a literature review and collect a basic information package for nurses about joint replacements as a treatment option for end-stage osteoarthritis. The aim of the thesis was to share the knowledge based on resent research work about hip and knee replacement implant materials including the associated benefits and risk factors.

2 HIP AND KNEE JOINTS

A joint, i.e. an articulation, is a place where two bones come together. Both hip and knee joints are freely movable synovial joints that contain lubricating fluid in a cavity surrounding the condyles of articulating bones (Figure 1). The condyles are covered with a layer of elastic hyaline cartilage providing smooth sliding surfaces. Cartilage has a very limited capacity for self-restoration and degradation of the bearing surface, e.g. in osteoarthritis, will result in a roughed joint surface that causes the pain and stiffness. A synovial membrane, i.e. synovium, lines the joint cavity and produces synovial fluid containing a mixture of polysaccharides, proteins, fat and cells. A joint capsule around the cavity helps to hold the bone ends together and allows movements. The hip and knee joint structures are reinforced and stabilized with ligaments and tendons. (VanPutte *et al*. 2010, 141; Vrahas *et al*. 2004.)

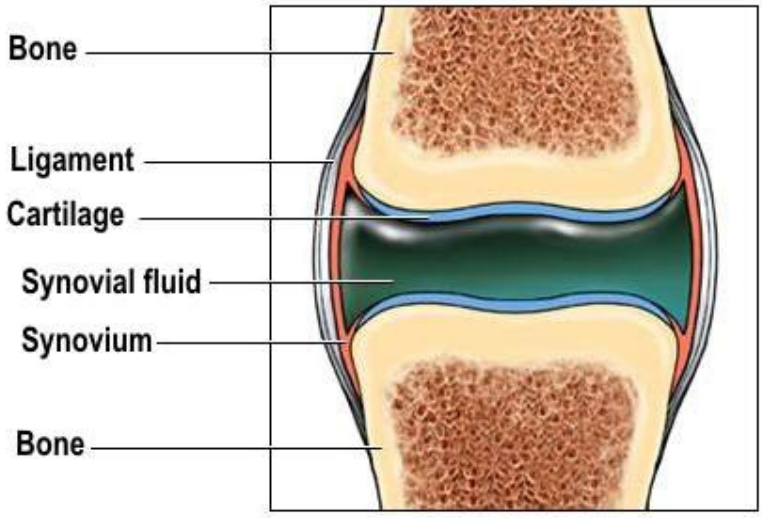


Figure 1. Structure of a synovial joint (Healthwise 2012).

The hip joint is the ball-and-socket joint between the femoral head (ball) and the cup-like acetabulum of the pelvis (Figure 2). The ball-and-socket joint allows a wide range of multi-axial movements. The primary function of the hip joint is to support the weight of the body in both static (e.g. standing) and dynamic (e.g. walking) postures. Hip joint is the largest weight-bearing joint in the body. (VanPutte *et al*. 2010, 141-143.)

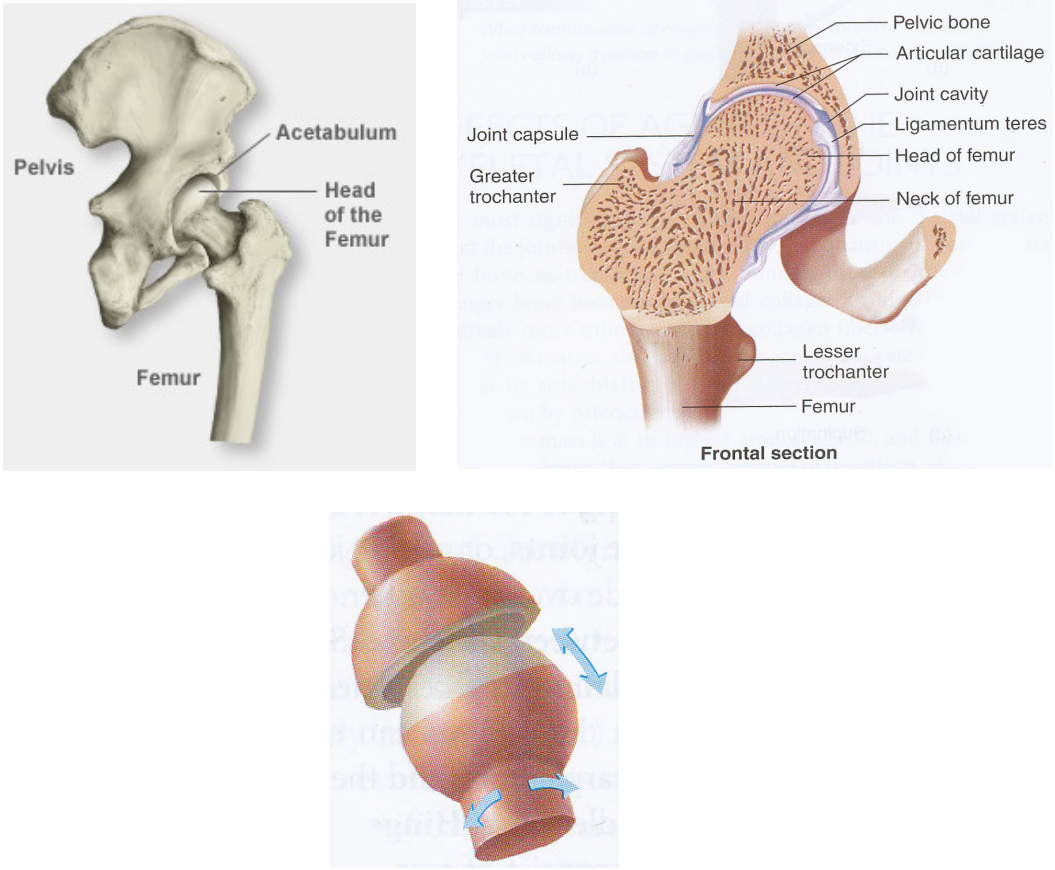


Figure 2. Hip joint: anatomy and a simplified illustration of a ball-and-socket joint Southern California Orthopedic Institute 2012; VanPutte *et al*. 2010, 142-143).

The knee joint which consists of two articulations, one articulation between femur and tibia and the other between the femur and the patella, is very complicated structure and the largest joint the human body (Figure 3). The knee joint is the pivotal hinge joint that permits flexion and extension as well as a slight medial and lateral rotation. The knee joint is very vulnerable since it supports nearly the whole weight of the body. (VanPutte *et al*. 2010, 141-143.)

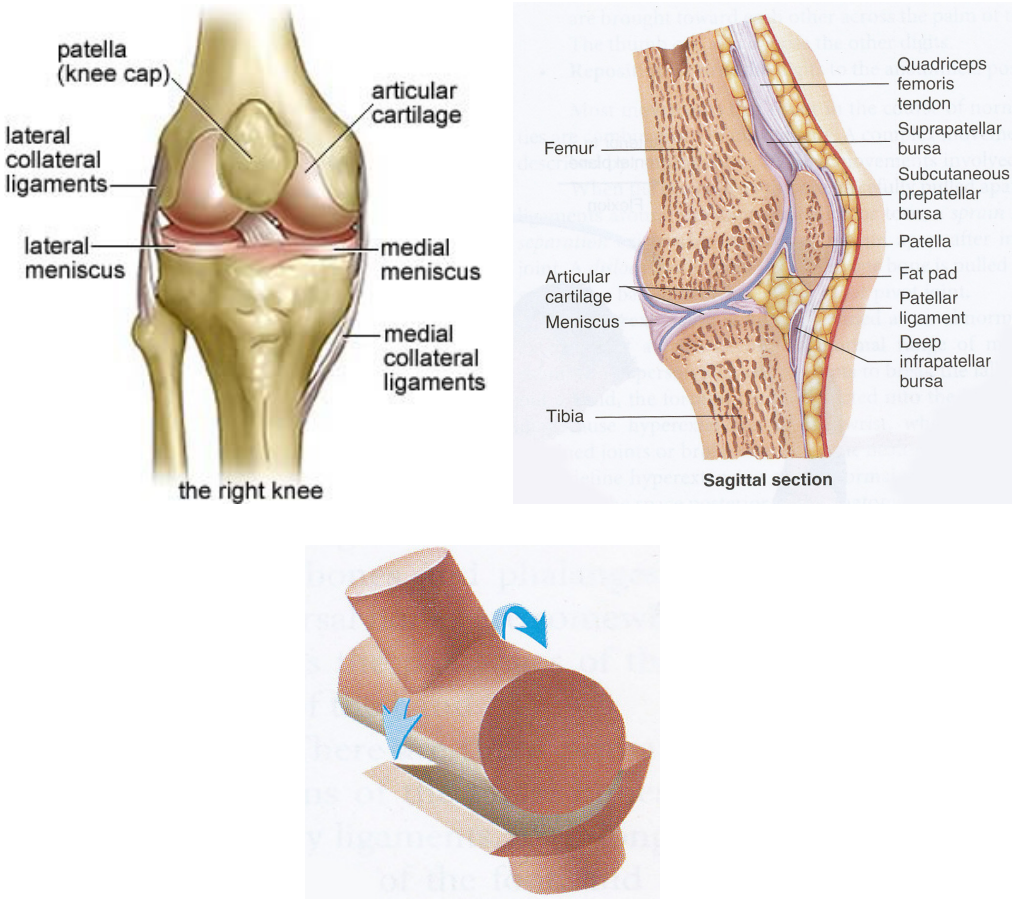
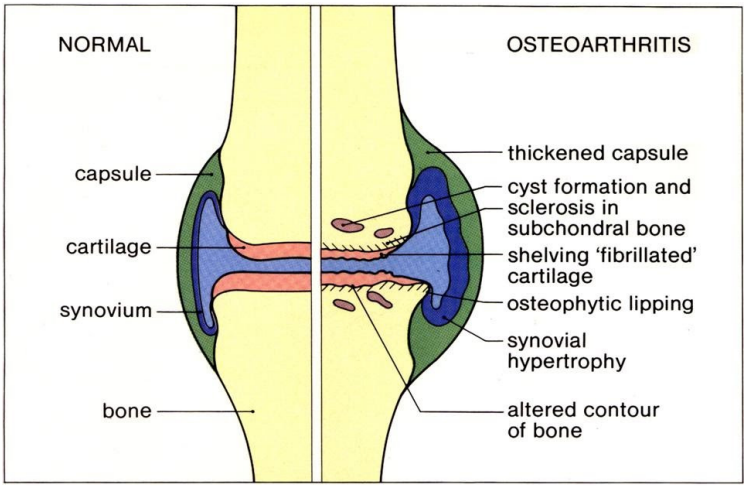


Figure 3. Knee joint: anatomy and a simplified illustration of a hinge joint (Frind, M. & SMG Medical Graphics 2011; VanPutte *et al*. 2010, 142-143).

3 OSTEOARTHRITIS

Osteoarthritis is a progressive joint disease that causes not only articular cartilage degradation but has also deleterious effects in the adjacent bone and other joint tissues. Even though osteoarthritis is classified as non-inflammatory joint disease, a mild synovitis may also play a role in the disease. Due to inflammation of synovium, the increased number of immune cells induces cytokines and proteases that can target the cartilage extracellular matrix and further accelerate the progression of osteoarthritis. (Sun 2010.)

The difference between a healthy joint and a joint affected by osteoarthritis is illustrated in Figure 4. Osteoarthritis causes radiographically identified bony changes such as joint space narrowing, the development of osteophytes, subchondral sclerosis and cyst formation. The clinical symptoms of osteoarthritis include joint pain, stiffness and swelling which can lead to impaired physical functioning and disability. The radiographic findings no not always correlate with the severity of the clinical symptoms. The progress of osteoarthritis can vary a lot but usually it takes several years until the symptoms are manifested. (The hip 2000; Sun 2010.)



Picture 4. Healthy joint vs. joint affected by osteoarthritis (Osteoarthritis 2012).

The cause of osteoarthritis is unknown. Osteoarthritis has a multifactorial etiology with several systemic factors generating susceptibility to osteoarthritis and interplaying with local factors determining the site and severity of the disease. One of the strongest systemic risk factors is advanced age due to cumulative exposure to various risk factors and normal biologic changes that makes joint less able to recover. Several studies have shown that osteoarthritis is strongly inherited with genetic influence as high as 50% – 65% particularly in osteoarthritis of the hand and the hip. Gender and hormones also play an important role as systemic risk factors of osteoarthritis. Women are more likely to have osteoarthritis of all joints than men and the disease is more severe in women. (Sun 2010; Zhang & Jordan 2010.)

Joint tissues are extremely sensitive to the biomechanical environment and mechanical loading within physiological range. Both overloading and underloading of the joints have catabolic effects. Moderate levels of exercise may be the most important single external factor responsible for maintaining joint homeostasis and cartilage integrity. The mechanical stimulation of the articular cartilage within physiologic range generates biochemical signals which increase anabolism of the chontrocytes. Excessive mechanical loading can shift the balance in chondrocytes to favor catabolic activity over anabolic activity and result in cartilage degeneration that may eventually lead to osteoarthritis. On the other hand, prolonged reduced mechanical loading due to joint immobilization can cause cartilage thinning, tissue softening and reduced proteoglygan content leading to cartilage matrix fibrillation, ulceration and erosion. (Grad *et al*. 2011; Sun 2010; Zhang & Jordan 2010.)

Obesity and overweight has been identified as one of the most important local risk factors of osteoarthritis, especially in case of knee osteoarthritis. Felson *et al*. (1992) demonstrated that weight loss about 5 kg had a 50% reduction in the risk of developing knee osteoarthritis in women. Various joint deformities may play a role in osteoarthritis. In the clinical study, conducted by Jacobsen and Sonne-Holm (2005), acetabular dysplasia was a significant risk factor for the development of hip osteoarthritis. Abnormal contact between the femoral head

and the acetabular margin (i.e. coxa vara / coxa valga) resulting in femoroacetabular impingement may be a contributing factor for osteoarthritis. Other important risk factors include joint injuries and occupation that requires repetitive carrying and kneeling or squatting. (Felson *et al*. 1992; Jacobsen & Sonne-Holm 2005; Tannast *et al*. 2008; Zhang & Jordan 2010.)

4 MANAGEMENT AND CARE OF OSTEOARTHRITIS

There is no curative treatment for osteoarthritis. The goal of osteoarthritis treatment is the management and alleviation of pain as well as the maintenance and improvement of functional capacity. (Polvi- ja lonkkanivelrikon Käypä hoito –suositus 2007.)

The treatments and management tools for osteoarthritis can be organized as a pyramid as seen in Figure 5. As the severity of osteoarthritis increases, treatments progress step by step, up the pyramid. Conservative non-drug treatments, such as appropriate guided physical exercises, patient education and weight-loss, represents the basis of care. The aim of the pharmacological treatment is to relieve pain and maintain physical activity. (Polvi- ja lonkkanivelrikon Käypä hoito –suositus 2007.)

Joint replacement is a demanding operation and the need for operation is always individually considered. Joint replacement may be considered if x-ray findings show an evidence of osteoarthritis, there is severe joint pain which is refractory to exercises and medicines or clinically observed considerable mobility restrictions or malposition of the joint that has a substantial impact on the quality of life and daily activities. (Polvi- ja lonkkanivelrikon Käypä hoito –suositus 2007; Vainikainen 2010, 32-40.)

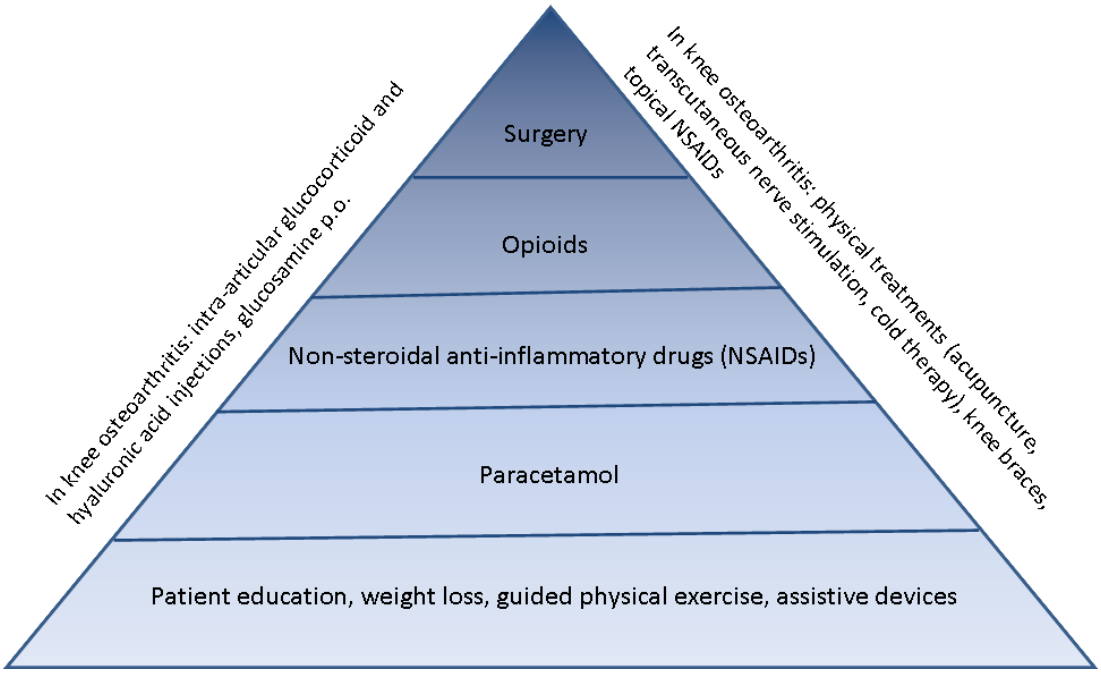


Figure 5. The care and management of osteoarthritis. The figure is modified from Polvi- ja lonkkanivelrikon Käypä hoito –suositus 2007 (www.käypähoito.fi).

5 JOINT REPLACEMENT TECHNOLOGY

5.1 Historical perspective

One of the pioneers of total hip replacement, i.e. total hip arthoplasty, was surgeon John Charnley from England. He developed the low friction total hip arthoplasty with a femoral component made of stainless steel and a plastic (polyethylene) acetabular socket. New acrylic bone cement technology, i.e. cold curing polymethylmethacrylate (PMMA) originally developed for dental applications, was used for fixation between the host bone and the artificial femoral and acetabular components. Charnley performed many successful hip replacement surgeries in the late 1950s and his method is still known today as a golden standard of total hip arthoplasty with long-term clinical follow-up results. (Revell 2008, 83-84.)

In late the 1960s at Sir John Charnley Hip Center, Frank Guston designed a metal-on-plastic knee joint that was fixed using bone cement. The first total knee arthoplasty, i.e. replacement of all three surfaces of the knee (the femur, tibia, and kneecap), was performed by John Insall in New York in the beginning of 1970s. (Revell 2008, 83-84.)

In the 1980s, Buchholz *et al*. added antibiotics to the bone cement in order to reduce the incidence of infection which was the most feared complication related to joint replacement. (Revell 2008, 212-213.)

5.2 Total hip arthoplasty

Total hip arthoplasty includes the removal of diseased femoral head and acetabular cup and replacing them with artificial components. The artificial components of the total hip arthoplasty may contain a metallic stem which fits into the proximal metaphysic and diaphysis of the femur, a metallic or ceramic ball replacing the femoral head, and an acetabular cup replacing the hip socket.

The acetabular cup can be non-modular, i.e. a single piece made of metal or polyethylene, or modular two-piece system with metallic shell in combination with a bearing surface liner made of polyethylene, metal or ceramic. The components of the total hip prosthesis are presented in Figure 6. (Mäkelä 2007; Pluot *et al*. 2009)

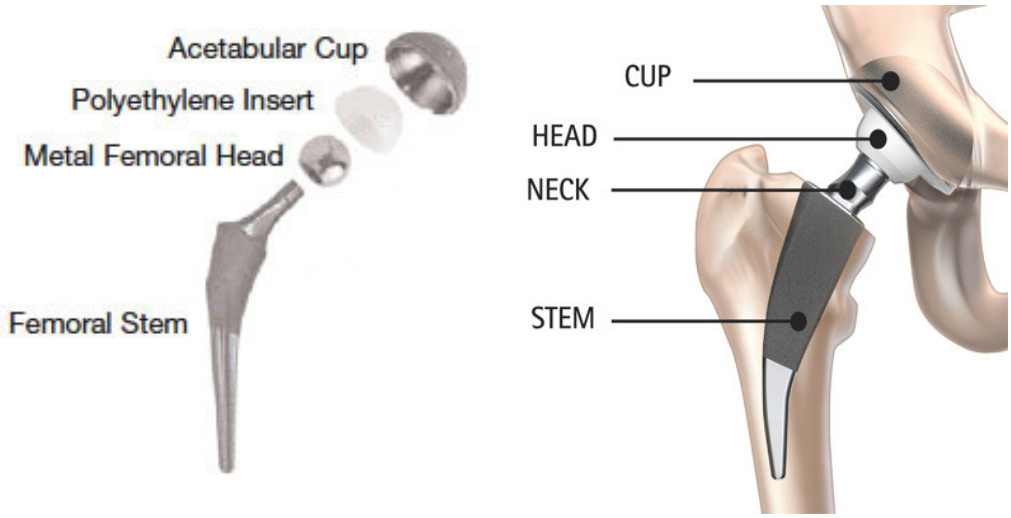


Figure 6. The components of the total hip prosthesis (Tri State Orthopaedics & Physical Therapy 2012; Aesculap Implant Systems 2012).

Fixation between the bone and the components of the total hip arthoplasty can be achieved with cemented or with cementless fixation methods.

Cemented fixation, i.e. mechanical interlocking, is achieved by press-fitting the implant using bone cement as a grouting agent (Figure 7). The metallic femoral components for cemented fixation have usually a smooth and polished surface. Cemented fixation method has many advantages: the method produces reliable outcomes in older patients (> 74 years), immediate loading of the limb is allowed, and bone cement can be used as a carrier matrix for antibiotics against

periprosthetic infections. Berry *et al*. (2002) reported 86.5% and Callaghan *et al*. (2009) found 78% survivorship of primary Charnley's total hip arthoplasty after 25 years and 35 years, respectively. On the other hand, cemented fixation is not usually recommended for young and active patient due high physical loading. (Berry *et al*., 2002; Callaghan *et al*. 2009; Konttinen & Santavirta 1999, 24-32; Mäkelä 2007; Mäkelä 2010.)

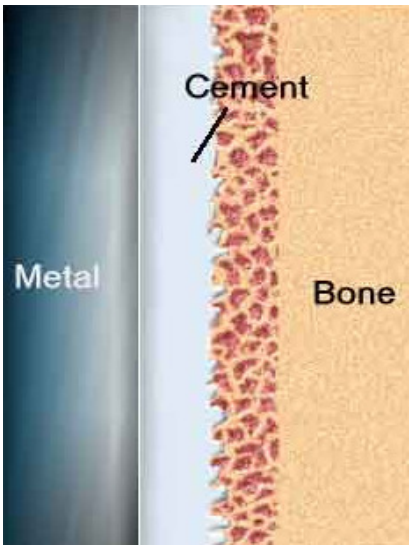


Figure 7. Schematic illustration of cemented fixation method (BME/ME 456 Biomechanics 2012).

Cementless fixation (Figure 8) may be achieved either by biological fixation, i.e. bone growth into the rough or porous surface structure, or by direct chemical bonding (e.g. using hydroxyapatite coating) between implant and bone. Cementless press-fit fixation was developed in an attempt to improve the longevity of implants, particularly in younger and more active patients. Several studies have demonstrated that minimum 15-year survival rate for cementless metallic femoral stems is 83% - 97%. The fixation process takes 2-3 months and during this healing period partial loading of the limb is often recommended.

Immediate unrestricted weight-bearing may cause micromovements at the bone–implant interface, jeopardising the stability of the prosthesis. On the other hand, partial weight-bearing may increase muscle atrophy and loss of bone mineral density, therefore inhibiting recovery. Markmiller *et al*. (2011) showed that partial weight-bearing may not be necessary after cementless total hip arthoplasty if solid initial fixation is achieved. (Bojescul *et al*. 2003; Kishida *et al*. 2001; Markmiller *et al*. 2011; Mäkelä 2007; Radl *et al*. 2000; Rajaratnam *et al*. 2008; Teloken *et al*. 2002.)

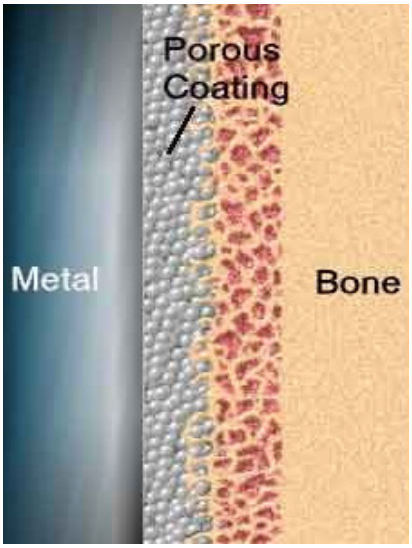


Figure 8. Schematic illustration of cementless fixation method (BME/ME 456 Biomechanics 2012).

5.3 Hip resurfacing

Hip resurfacing (Figure 9) is an alternative bone preserving hip joint replacement technique for young and physically highly active patients with severe osteoarthritis, good hip morphology and reasonable bone quality. The surface of the femoral head is replaced by a cemented metallic bearing surface without removing the femoral neck. A cementless metallic acetabular cup is also inserted. McMinn *et al*. (2011) reported 13-year hip resurfacing survival rate of 97% in women and men above 60 years and also for men under 60 years. However, for women under 60 years, the survival rate was only 92%. Lower survivorship may be related with hip dysplasia which is common in younger women. Femoral neck collapse and fractures were the most common reason for failure. On the contrary, Naal *et al*. (2011) demonstrated low survival rates, 88.2% for all patients and 81.5% for women, only five years after hip resurfacing. (Halonen 2010; McMinn *et al*. 2011; Mäkelä 2007; Naal *et al*. 2011; Pluot *et al*. 2009.)

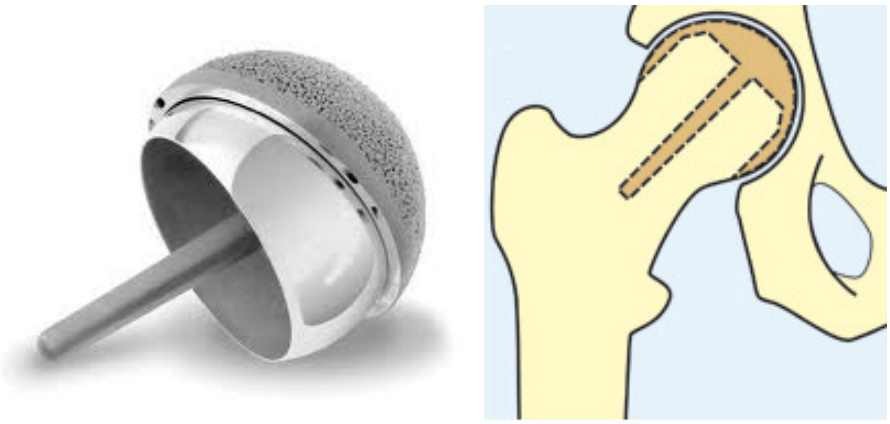


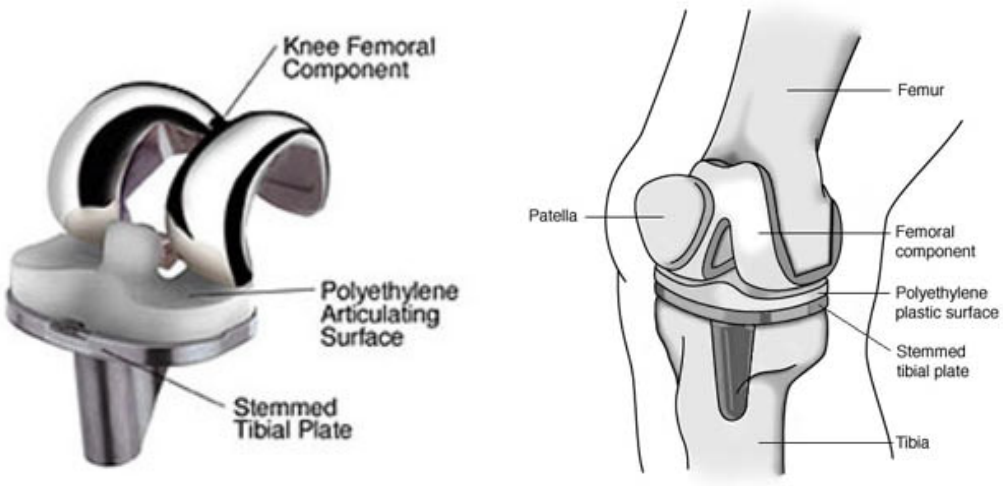
Figure 9. Hip resurfacing prosthesis (SurfaceHippy Hip Resurfacing 2012; The McMinn Centre, UK 2012).

5.4 Total knee arthoplasty

Total knee arthoplasty may include femoral, tibial and patellar parts. If only one part (i.e. medial or later) of the knee joint is damaged, the unicompartmental knee replacement can be done in order to save the healthy part. The components of the total knee prosthesis are presented in Figure 10. (Konttinen & Santavirta 1999, 42-48.)

In total knee arthoplasty, the joint surface of diseased femoral condyle is replaced with a metallic round ended femoral component mimicking the curvature of the natural femoral condyle. Fixation of the femoral component may be achieved with bone cement or using cementless method with the help of porous surface structure or e.g. hydroxyapatite coating of the implant. (Konttinen & Santavirta 1999, 42-48; The knee 2000.)

A flattened or slightly dished tibial component made of polyethylene replaces the destroyed articulating surface. Patellar components are also made of polyethylene. The tibial component often contains also a metallic back-up plate which minimizes the deformation of the polymer component under loads. The metallic back-up plate may have an intramedullary stem which further stabilizes the structure. All-polyethylene tibial components are also available in the market. Cemented fixation or cementless fixation with screws and pegs can be used with the tibial component. (Konttinen & Santavirta 1999, 42-48; The knee 2000.)



Picture 10. The components of the total knee prosthesis (American Academy of Orthopaedic Surgeons 2012; Edwin P 2012).

Cemented fixation method of total knee arthoplasty components is generally favored over cementless fixation due to the low rates of aseptic failure in long-term follow-ups. Several studies demonstrated good clinical results at 15 years with the survival rates of 98.9% - 100%. The lower cost of cemented components offers also an economic advantage. (Bauer & Schils 1999; Berger *et al*. 2001; Keating *et al*. 2002; Lombardi *et al*. 2007.)

There are several different implant designs available for total knee arthoplasty. In this study, only two implant designs are presented: a fixed-bearing design and a mobile-bearing design. The fixed-bearing total knee arthoplasty is suitable for most of the patients. The polyethylene tibial component is firmly attached to the metallic back-up plate. The femoral metallic component rolls on this cushioned surface. In some cases, excessive activity can cause more rapid wear down of the fixed-bearing prosthesis. (Konttinen & Santavirta 1999, 42-48; Revell 2008, 491-493.)

The mobile-bearing knee prosthesis may be a choice for younger and more active patients. The polyethylene insert can rotate short distances inside the metal tibial back-up plate. This rotation reduces stress and wear on the implant and allows for a more natural range of knee motion. Mobile-bearing knee implants require more support from soft tissues, i.e. the ligaments surrounding the knee, than fixed-bearing design. If the soft tissues are not strong enough, mobile-bearing knees are more likely to dislocate. (Deirmengian & Lonner 2010; Revell 2008, 491-493.)

6 BIOMATERIALS FOR JOINT REPLACEMENT

6.1 General requirements for biomaterials in joint replacement

Materials used in joint replacement must fulfill the strict requirements for biocompatibility and mechanical properties under the corrosive environment of the human body.

Biocompatibility is defined as the ability of a material used in a medical device to perform with an appropriate host response in a specific application. Implant materials must be non-toxic, non-irritant, non-allergenic and non-carcinogenic. On the other hand, positive reactions between host bone and biomaterials, such as osteoinduction, osteoconduction and osseointegration, are beneficial in order to improve the function of the implant in the body. (Törmälä 2001, 23-27; Williams 1999)

High compression, bending and torsional strength, fracture toughness, wear resistance at sliding surfaces, and fatigue resistance under cyclic loading are some of the most important requirements for mechanical properties of the joint replacement materials.

6.2 Metallic components

Cobald-chromium (CoCr) and its alloys (e.g. CoCrMo), or titanium (Ti) and its alloys (e.g. Ti-6Al-4V) are the metals used nowadays as weight-bearing components in joint replacements. These materials have several advantages if used as joint replacement implants: complex shapes can be produced by standard machining procedures, metallic materials have in general high strength (Figure 11a), high fracture toughness, hardness, corrosion resistance and biocompatibility. However, disadvantages also exist. The elastic modulus of the conventional metallic implant materials is very high compared with the elastic modulus of bone (Figure 11b). After the operation most of the load is

carried by the metallic implant due to its higher stiffness and the bone is left virtually unstressed. This phenomenon is known as stress-shielding effect. The mechanical stimulus is needed to maintain the structural integrity and morphology of the bone, and lack of it causes bone resorption and loosening of the implant. (Huiskes & Nunamaker 1984; Huiskes *et al.* 2000; Revell 2008, 84-85.)

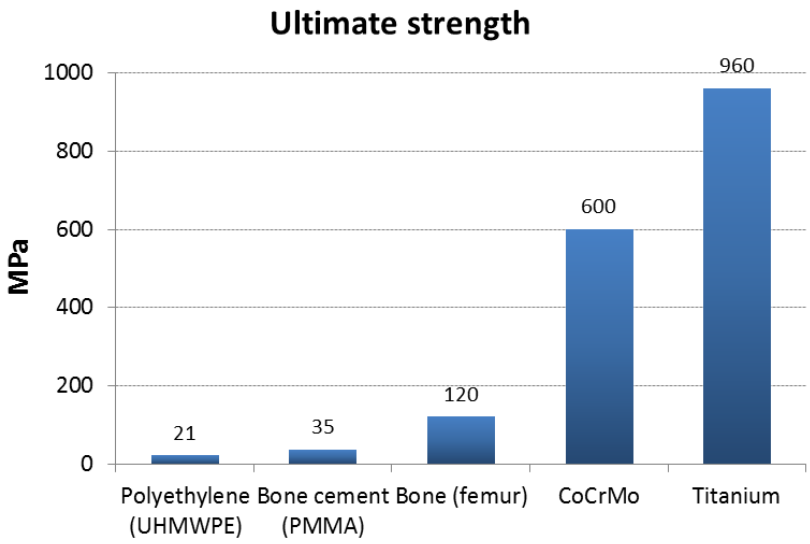


Figure 11a. The ultimate strength of cortical bone and some commonly used biomaterials in joint replacements The figure modified from An & Draughn, 2000, 41-63; Revell, 2008, 82, 86, 88. Note! The values of the mechanical properties of synthetic materials depend on processing techniques.

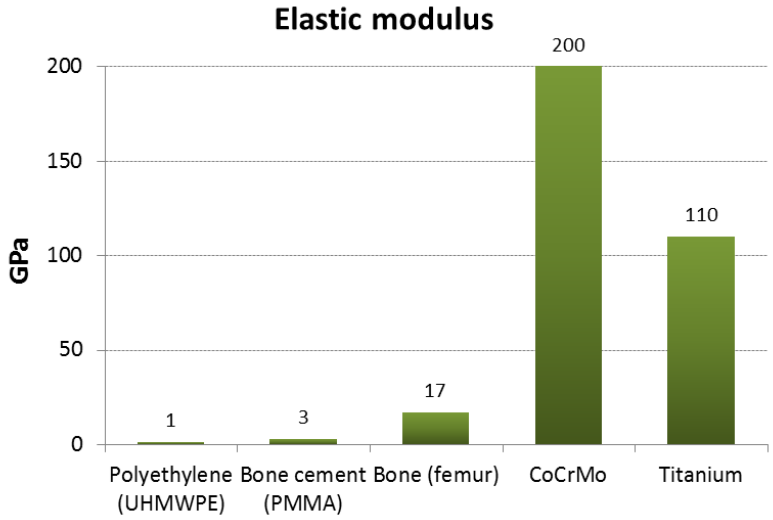


Figure 11b. The elastic modulus of cortical bone and some commonly used bio-materials in joint replacements. The figure modified from An & Draughn, 2000, 41-63; Revell, 2008, 82, 86, 88. Note! The values of the mechanical properties of synthetic materials depend on processing techniques.

A proper and permanent fixation between bone and the implant is crucial in order to transfer the load from the implant to bone within physiological range. Surface characteristics, such as chemical composition and surface topography of the implant, and mechanical conditions at the implant-bone interface determine the reactions with the surrounding biologic environment. In joint replacements, cemented or cementless fixation methods can be used. In cemented fixation, the bone cement fills the gap between the implant and bone forming an interface which can transfer the forces between the implant and the bone. In cementless fixation, the surface topography of the implant can be modified by making the surface rough (e.g. using grit-blasting) or porous (e.g. by sintering or plasma treatment). Bone ingrowth into the porous surface of the implant stabilises and gives significant strength to the bone-implant interface and therefore improves the clinical success. *In vivo* experiment by Bobyn *et al.* (1980), revealed that a pore size range of 100 - 400 µm provided the maximum

fixation strength. (Bobyn *et al*. 1980; Rand & Dorr 1986, 236-248; Søballe *et al.* 1990.)

The elastic modulus of Ti-6Al-4V alloy is roughly a half of the elastic modulus of cobalt alloys (figure 11b), and much closer to the biomechanical properties of bone. Therefore enhanced load transfer between titanium-based implants and surrounding bone can be achieved. Titanium alloys have an excellent corrosion resistance and biocompatibility. A protective oxide layer is formed spontaneously on the surface of titanium-based implants and that phenomenon also creates a capability to enhance osteoblast activity. Titanium-based implants are favoured in cementless joint replacements due to their capacity for direct chemical bonding with bone, i.e. osseointegration. A hydroxyapatite coating on the titanium-based prosthesis can be used to further improve cementless fixation. One disadvantage of titanium-based implants is that they are softer and therefore more susceptible to wear than implants made of cobalt-based materials. For that reason, titanium-based alloys cannot be used as bearing surfaces of joint prosthesis. (Konttinen & Santavirta 1999, 15-22, 32-33; Revell 2008)

Cobalt alloys have a very high elastic modulus (Figure 11b) in comparison with the biomechanical properties of bone. Therefore implants made of cobalt alloys with smooth and polished surfaces are mainly used in cemented joint replacements. Bone cement transfers the forces between the implant and bone. Bone cement may also provide a shock-absorbing layer between elastic bone and the stiff metallic implant and therefore conflict between mismatching mechanical properties is decreased. Cobalt alloys are suitable materials for artificial articulation surfaces due to their better wear resistance compared with titanium-based alloys. One concern related to cobalt-based implants is the toxic effects of ions released from the metal, e.g. cobalt and chromium which can cause allergic reactions. (Konttinen & Santavirta 1999, 15-22; Revell 2008, 84-85; Webb & Spencer 2007.)

6.3 Hydroxyapatite coatings

Hydroxyapatite is a naturally occurring mineral and its chemical composition is quite similar with the inorganic component of bone that is formed from carbonated hydroxyapatite. Hydroxyapatite is a reactive and osteoconductive ceramic with excellent biocompatibility. In the body, the resorption of hydroxyapatite is a slow process and degradation products are intoxic. Hydroxyapatite coating of metallic implants in cementless joint arthoplasty allows a direct strong chemical bonding between the implant and bone in order to enhance a proper fixation. Vidalain (2011) reported 96.3% survival probability at 23 years for hydroxyapatite coated Ti-6Al-4V femoral component in hip arthoplasty. (Konttinen & Santavirta 1999, 32-33; Vidalain 2011.)

6.4 Bearing surfaces

Several requirements have to be fulfilled while bearing couples, i.e. the combination of artificial articulation surfaces, are designed. These materials must show biocompatibility, low friction and wear rates (Figure 12), good lubrication properties, shock absorber capacity, good corrosion resistance in synovial fluid and long-term degradation resistance. In knee arthoplasty, metal-on-polyethylene bearing couple is the most dominant option, although ceramic-on-polyethylene option is under re-evaluation (Heimke *et al*. 2002).

In hip arthoplasty, there are several possible bearing couple combinations available that are listed below in the order of decreasing popularity (Tailor *et al*. 2010):

- polyethylene acetabular articulation – metallic femoral head
- polyethylene articulation articulation – ceramic femoral head
- ceramic articulation articulation – ceramic femoral head
- metallic articulation articulation – metallic femoral head
- metallic articulation articulation – ceramic femoral head

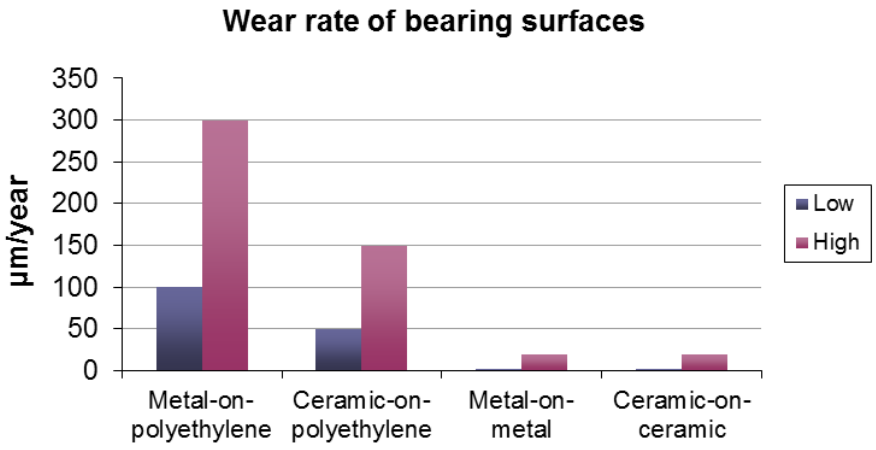


Figure 12. The highest and lowest linear wear rates of various bearing surfaces. The figure modified from Semlitsch & Willert 1997.

Polyethylene

Polyethylene (PE) which has been used for 50 years in joint replacements is still the most widely used bearing surface. Polyethylene is an inert material. Polyethylene wear rate, 100-300 µm/year for metal-on-polyethylene bearing surfaces, is an unpredictable process and many factors can affect polyethylene longevity. Ceramic-on-polyethylene bearing surfaces have a lower wear rate (Figure 12) but the risk for fractures is increased. Sliding properties of polyethylene has been improved by creating cross-linked ultra-high molecular weight polyethylene (UHMWPE) including the addition of vitamin E to reduce oxidative damage. UHMWPE is one of the most preferred polymers as an orthopedic implant because of its high mechanical strength and biocompatibility. However, despite all material modification, foreign body reactions, osteolysis and loosening of the implant due to polyethylene wear debris is a major concern in joint replacement technology. In hip arthoplasty, smooth and polished metallic or ceramic femoral head components are essential in order to reduce friction and wear on polyethylene surface. Obesity, high physical activity, malalignment of joint replacement components and roughness at articulating surfaces can have an effect on stress/strain distribution, increase wear and probability for fractures on polyethylene surface. (Konttinen & Santavirta 1999, 22-24; Oral & Muratoglu 2010; Revell 2008, 88-90, 178-180; Semlitsch & Willert 1997.)

Metal-on-metal

All metal-on-metal joints are made of cobalt-based alloys. It has been found that low wear rate (Figure 12) on metal-on-metal bearing surfaces reduced the loosening tendency of the total hip prosthesis. In comparison with conventional metal-on-polyethylene bearing surfaces, metal-on-metal system has one remarkable advantage which is the possibility to design a hip prosthesis mimicking the normal dimensions of the hip: a larger head size with a diameter of 44 - 54 mm can be used in order to reduce the risk for dislocation without

increasing the wear rate significantly in spite of longer sliding distance. (Revell 2008, 180-182.)

Metal-on-metal bearing surface may be an option for young and active patients with hip osteoarthritis. However, the disadvantages of metal-on-metal bearing surfaces also exist. Increased blood serum and urine cobalt and chromium levels have been measured. These potentially toxic metal ions, released by corrosion, are eliminated from the body by the kidneys and it has been recommended that patients with chronic renal failure should not have metal-on-metal bearing surfaces in their total hip prosthesis. Released metal ions can cause, local tissue reactions, pain and swelling in the hip area, and are associated with premature prosthetic failure. The chromium levels were significantly lower when ceramic-on-metal combination was used in comparison with metal-on-metal bearing surfaces. (De Haan *et al*. 2008; Isaac *et al*. 2008; Triclot 2010.)

Ceramic-on-ceramic

Aluminium oxide (Al_2O_3) and zirconium oxide (ZrO_2) are the most widely used ceramics on bearing surfaces. Ceramics, known as brittle materials with extreme hardness, have shown very low wear rates (1-3 µm/year for aluminium oxide-on-aluminimum oxide), and excellent lubrication and friction properties. Only a little cellular reactions to wear debris have been detected in comparison with other bearing surfaces. Ceramic-on-ceramic bearing couples may be an option for especially for young and active patients. Several solutions have been developed to overcome the problem with socket fixation in total hip arthoplasty. One of the most promising options is the press-fit hydroxyapatite-coated titanium shell with ceramic modular insert. The major drawback of ceramics is the low fracture resistance: a single critical flaw in the structure can lead to the complete catastrophic failure of the implant because the material has no possibility to deform. (Hannouche *et al*. 2011; Revell 2008, 182-183.)

6.5 Bone cement

Polymethylmethacrylate (PMMA) based bone cements can be used for the fixation of the joint prosthesis. It fills the gap between the implant and bone forming an interface which can transfer the forces from the implant to bone and vice versa. PMMA bone cement is a two-component system: polymer (PMMA) powder and monomer (methylmethacrylate, MMA) liquid are mixed together at the operation theatre just before the use. The system contains initiators and activators which start the polymerization reaction when components are mixed. Mixing is done under vacuum in order to reduce the porosity of the bone cement which can cause a failure when subjected to mechanical loading. The pressurized cement is injected into the bone before inserting the prosthesis. Pressurization has a positive influence on the penetration of the bone cement into the cavities of the bone. (Revell 2008, 212-242.)

Other components of bone cements are an inhibitor to avoid premature polymerization during storage, additives, e.g. dye, radiopacifier which make it easier to monitor the healing and loosening processes with x-ray imaging techniques after joint replacement surgery. The usage of radiopacifiers, such as $BaSO_4$ and ZrO_2, can cause some troubles, such as releasing of toxic barium ions and migration of cement particles containing abrasive ZrO_2 into the joint articulation where it can produce polyethylene wear debris. The acrylic bone cement may contain also antibiotics, e.g. gentamicin, tobramycin, vancomycin and clindamycin against periprosthetic infections. (Revell 2008, 212-242.)

The polymerization of PMMA bone cement is highly exothermic and therefore it has been hypnotized that thermal necrosis of the surrounding tissue can occur and may play a role in aseptic loosening of cemented joint prosthesis. On the other hand, Tolksvig-Larsen *et al*. (1991) measured the temperature at the bone-cement interface during cement curing in joint replacement surgeries and found that the mean peak temperatures, 40 - 46°C, were significantly lower than the values measured *in vitro* experiments. PMMA bone cement has a tendency to shrink during polymerization and it can have a negative effect on the stability of the prosthesis. A volumetric shrinkage of 3-5% after curing of acrylic bone

cement may potentially compromise the bone-cement interface. However, water sorption of 1-2% of PMMA bone cement *in vivo* counteracts with polymerization shrinkage. Potentially harmful unreacted MMA monomers (2-6%) which are trapped within the polymer during the polymerization process may leach out from the bone cement *in vivo* and cause chemical necrosis. (Revell 2008, 212-242; Tolksvig-Larsen *et al*. 1991.)

A transient fall of blood pressure can be noticed during the joint replacement surgery shortly after inserting bone cement into medullary canal of femur. Parvizi *et al.* (1999) found 0.08% intra-operative mortality rate during cemented hip replacement surgeries. One possible reason might be fat and bone marrow embolism due to pressurization, femoral component implantation and hip reposition. (Parvizi *et al.* 1999.)

7 PROSTHETIC JOINT LIFESPAN

7.1 Normal tissue responses after implantation

Normal tissue responses after the joint replacement can be divided in six phases: injury, hemostasis (platelet aggregation and clot formation), inflammation, proliferation, granulation tissue formation, and remodeling. Insertion of the hip or knee joint prosthesis that requires sawing, drilling and reaming is a traumatic process to tissues. (Park & Lakes 2007, 265-278; Revell 2008, 315-323.)

Inflammation is a normal response to tissue injury that is characterized by changes in permealibility of blood vessels and by the emigration of granulocytes and macrophages to affected area in order to start the phagocytosis of necrotic tissue, foreign material and micro-organisms. (Park & Lakes 2007, 265-278; Revell 2008, 315-323.)

In the next phase new blood vessels and collagenous connective tissue, i.e. granulation tissue, are formed. Granulation tissue has potential to differentiate to form woven bone, cartilage or fibrous tissue depending on local conditions, e.g. mechanical loading. Therefore granulation tissue can be called also as primitive mesenchymal tissue. (Bobyn *et al.* 1980; Park & Lakes 2007, 265-278; Revell 2008, 315-323.)

In the final phase, bone remodels to produce secondary lamellar bone and also to fit the shape of the implant. Biomechanical conditions and micromotions have a major impact on the remodeling process of the bone at the bone-implant interphase. Certain stress/strain conditions are required to promote new bone growth and to prevent bone resorption. Both over and under loading have detrimental effects on bone remodelling. (Bobyn *et al.* 1980; Huiskes *et al.* 2000; Park & Lakes 2007, 265-278; Revell 2008, 315-323.)

7.2 Failure mechanisms

In Finland, the revision surgeries constituted 14.2% of all hip arthoplasties and 7.0% of all knee arthoplasties in 2010 (Perälä 2011). There are several factors affecting the long-term results of joint replacements, including material properties of implants (i.e. surface roughness, porosity, chemistry, wear rate, elastic modulus), implant design, and local biomechanics. In addition, the right patient choice and professional skills of the operation team have an influence on the results.

The most common reasons for revision surgeries are aseptic implant loosening, periprosthetic fractures, dislocation or malalignment of the prosthesis, implant failure and infection. Due to improved material properties, processing methods and implant design, the incidence for implant fractures have diminished dramatically. (Perälä 2011; Revell 2008; 275-276.)

The Finnish national endoprosthesis register, maintained nowadays by National Institute for Health and Welfare, started its documentation of primary and revision surgery on major joints in 1980. The statistical follow-up studies of the number and quality of the joint replacement surgeries based on the endoprosthesis register data are valuable tools when the quality and productivity of health care services are evaluated. (Perälä 2011.)

Aseptic loosening of prosthesis

Aseptic loosening of the endoprosthesis occurs when there is no evidence of infection. The aseptic failure rates can be as high as 20%. Prosthetic loosening is painful and reoperation may be required to exchange loose components. Abrasion of wear particles, micromotions, and stress shielding at the implant-bone interface can inhibit bone incorporation with the implant. Wear debris particles from bone cement, polyethylene and metals can invade from the articular surface to the bone-implant interface and induce inflammatory reactions, activate macrophages and osteoclasts, and initiate accelerating

periprosthetic bone resoption. In the recent study based on Finnish endoprosthesis register analysis, Mäkelä (2010) demonstrated that excessive polyethylene wear was a major clinical problem with modular cementless cups in primary total hip arthoplasties. (Huiskes & Nunamaker 1984; Mäkelä 2010; Revell 2008, 264-267; Søballe *et al*. 1992; Sundfeldt *et al*. 2006.)

Micromotions, i.e. small movements between the implant and surrounding bone, have a negative influence on bone growth and a positive influence on the formation of connective tissue. Micromotion due to joint loading is an important factor in progressive interface debonding of cemented and cementless hip prosthesis. (Huiskes & Nunamaker 1984; Rand & Dorr 1986, 236-248.)

The mismatch of mechanical properties between metallic implant (elastic modulus, up to 200 GPa) and bone (17 GPa) causes a phenomenon called stress-shielding, i.e. underloading of bone, that can lead to disturbances in bone remodeling, bone resorption and loosening of the implant. A proper fixation between the implant and bone must be achieved in order to minimise micromotions and transfer the load between the implant and surrounding bone within physiological range. (Huiskes & Nunamaker 1984; Søballe *et al*. 1992.)

Periprosthetic fractures

Periprosthetic fractures can be divided as intra-operative and post-operative fractures. There is an increased risk of periprostetic bone fractures in patients who have a metabolic bone disease (i.e. osteoporosis or osteomalacia) or are prone to injury (i.e. elderly patients, patients with neurological deficits, alcoholics). The incidence of periprosthetic fractures is much higher in revision surgeries vs. primary surgeries and in press-fit cementless fixations vs. cemented fixations. The stress-shielding effect increases the risk periprosthetic fractures since it affects on bone remodeling and healing process leading to increased bone porosity. Periprosthetic fractures can be treated operatively with osteosynthesis and bone grafts or with restricted weight-bearing, immobilization

and radiographic follow-ups depending of the site and type of the fracture. (Revell 2008, 267-275.)

Dislocation of prosthesis

The incidence of dislocation of prosthesis is 2-4% after primary joint replacement surgery, but can be as high as 7.4% after revision surgery. There are several factors which decrease the probability of hip prosthesis dislocation: good surgical technique, optimized component positioning, increased femoral head size, and sufficient abductor muscle function in order to provide the stability of the hip. However, bigger femoral head size may increase the wear rate. Wear of the joint replacement prosthesis may change the biomechanics and range of motion of the joint causing dislocation or impingement of the prosthesis and osteolysis. (Meek *et al*. 2006; Revell 2008, 276-279.)

Patient education has an essential role in the prevention of prosthesis dislocations because the risk of dislocation not only extends over the lifetime of prosthesis but also increase with time. The patient should be taught to avoid extreme movements, i.e. extreme rotation, flexion, adduction, of the affected limb after joint replacement operation. A special attention should be paid on the elderly patient, and patients with cognitive dysfunction or alcohol abuse problems. (Revell 2008, 276-279; von Knoch *et al*. 2002.)

Infections

An increasing concern in orthopedic surgery is the insurgence of bacterial infection at the implant site. The rate of periprosthetic infections varies between 0.6% and 1.3% after total hip replacement surgery. Bacterial infections could arise from a direct contact of the implant with bacterial strains during its insertion but, since the implant site represents a weak point in the host organism, could migrate from different sites and localize at the implant-

organism interface. (Bohm *et al*. 2012; Gastmeier *et al*. 2005; Phillips *et al*. 2006.)

Early periprosthetic infections by, for instance, *Staphylococcus aureus* and *Staphylococcus epidermidis* and later predominantly by more indolent organisms such as *Propionibacterium acnes* demand for treatment by systemic antibiotics. Local prophylactic antibiotic treatment, e.g. antibiotic loaded bone cement, is needed because bacteria may form a protective biofilm with low sensitivity to antibiotics. The golden standard in deep periprosthetic infection management is implant removal, debridement and antibiotic therapy delivered both systemically and locally using antibiotic-loaded spacers. However, spacers may expose patients to new complications, such as spacer dislocation, or spacer and femoral fractures. Due to the outbreak of antibiotic resistant bacterial strains, intensive research has been focused on the development of alternative antimicrobial agents. (Matthews *et al*. 2009; Senthi *et al*. 2011.)

7.3 Roentgen stereophotogrammetric analysis (RSA)

Roentgen stereophotogrammetric analysis (RSA) is an accurate method to localize the 3D position and measure the micromovements of the orthopedic prosthesis using x-rays. This method requires insertion of x-ray opaque markers, ie. small inert tantalum beads, in the bone and prosthesis at the time of surgery to serve as the artificial landmarks. (Campbell *et al*. 2011; Kärrholm *et al*. 2006.)

With the help of a calibration cage, also marked with tantalum markers at accurately known positions, and two separate x-ray sources simultaneously obtaining a stereo image of bone and prosthesis, micromotions (rotation and translation) at the prosthesis-bone interface can be very precisely determined. These measurements may help to predict loosening of the prosthesis and the need for revision surgery. (Campbell *et al*. 2011; Kärrholm *et al*. 2006.)

8 PATIENT OUTCOMES AFTER ARTHOPLASTY

The artificial joint is never as good as the person's own healthy original joint would be. However, both total hip arthoplasty and total knee arthoplasty are highly successful procedures for end-stage osteoarthritis. The majority of the patients think that the quality of life has been improved after the joint replacement. Advances in materials technology, implant design and surgical procedures have dramatically improved the outcomes after total joint replacements over the past decades. (Vainikainen 2010, 40; Wylde *et al*. 2007.)

Baker *et al*. (2007) studied the results of questionnaires filled in by 8 231 patient who had undergone primary unilateral total knee arthoplasty in April - December 2003 in England or Wales. The most common severe problems after knee arthoplasty were related to kneeling (57% of the patients), persistent pain (19.8%), pain on walking (16.6%), and shopping (16%). Majority (81.8%) of the patients were satisfied, 11.2% were unsure and 7% were unsatisfied with the results of knee arthoplasty. It was found that low pain score and high physical function score after knee arthoplasty correlates with satisfaction. 70-80 year old patients were more satisfied than younger patients aged less than 65 years. Men were more likely to be satisfied after knee operation than women. Pre-operative diagnosis, ASA grade and implant type seem to have also an effect on the level of patient satisfaction. (Baker *et al*. 2007.)

Rolfson *et al*. (2009) analyzed pre-operative and one year post-operative data from the Swedish Hip Arthroplasty Register, including 6 158 patients with primary osteoarthritis of the hip. The authors demonstrated that patients with pre-operative anxiety and depression reported not only the high pre-operative pain scores but also persistent discomfort and greater dissatisfaction after hip replacement. Patients suffering from anxiety and depression also demonstrated poor improvement according to mobility scores. This phenomenon is known as kinesiophobia, i.e. pain related fear or anxiety become more disabling than the pain itself. (Rolfson *et al*. 2009)

According to Gonzalez Sáenz de Tejada *et al*. (2010), patient's waiting for total joint replacements had high pre-operative expectations for the benefits of surgery. Patients expected improved ability to walk (96.1% of the patients), pain relief (95.3%), doing more daily activities (89%), improved physiological well-being (87%) and improved capacity to interact with others (80.7%). However, less than 50% of the patients had fulfilled their expectations at 3 months after operation. At 12 months, the results were slightly better. On the other hand, there were more than 30% of the patients who reported that their expectations had not been fulfilled probably due to over-optimistic expectations. (Gonzalez Sáenz de Tejada *et al*. 2010)

Knee articulation is more complex than hip articulation and therefore patients with osteoarthritis usually experience fewer benefits from total knee arthoplasty than from total hip arthoplasty. Patients experience generally faster and greater improvements in function and pain after total hip arthoplasty (in first three months) than after total knee arthoplasty (can take up to one year). Patients also experience less chronic post-operative pain, have better functional ability and social functioning, and show greater satisfaction after total hip arthoplasty compared with the situation after total knee arthoplasty. At the moment, it is uncertain why some patients experience a poor outcome, i.e. severe medically unexplained pain, after total knee arthoplasty. There might be several risk factors related to various medical, biological and psychosocial issues. One important factor related to outcomes of total joint replacements might be the right timing of the surgery. Earlier surgeries for the patients whose functional status has not been deteriorated to excess may be associated with better outcomes. (Fortin *et al*. 2000; Wylde *et al*. 2007.)

9 TASK AND AIM OF THE STUDY

The task of this bachelor thesis was to do a literature review and compile an information package for nurses on the knee and hip replacement technology.

The aim of the thesis was to share the knowledge based on resent research work about hip and knee replacement implant materials including the associated benefits and risk factors.

10 METHODS AND IMPLICATION OF THE STUDY

The commissioner of this thesis (Appendix 1) was the University of Turku, Department of Nursing Science. Selection of the topic was based on author's educational background as a materials engineer and work experience in the field of biomaterials science. This study was focused on the properties of various implant materials, their performance in biological environment and possible fixation methods used in primary hip and knee arthoplasty according to the requests by the commissioner.

This study combines the knowledge obtained in the fields of materials science, biomedical engineering and nursing. SciFinder Scholar research discovery tool, which allows searching from CAplus and Medline databases, was used as the main resource for research articles, reviews and books. Several keywords were used for the search on Scifinder such as osteoarthritis, treatment/care for osteoarthritis, hip/knee arthoplasty, hip/knee joint replacement, bearing surfaces in hip/knee joint replacement/arthoplasty, bone cement, hip/knee joint replacement failure, failure of hip/knee joint replacement/arthoplasty, patient outcomes/opinions/satisfaction after hip/knee joint replacement/arthoplasty. Special requirements for revision surgeries were excluded from this study.

Literature review for the thesis was done on the basis of relevant recently published (2000-2012) research articles, review articles and books. Some older articles were also included due to their importance.

A short introduction in Finnish and link for this thesis was added to a public internet webpage called Hoitonetti which provides information for the health care professionals. The information package mainly targets the nurses working with patients who need hip or knee joint replacement.

11 RELIABILITY AND ETHICAL CONSIDERATIONS

This thesis was based on literature review and was written according to the rules and regulations of Turku University of Applied Sciences. As an engineer and research scientist, the author has both hands-on experience and theoretical knowledge about biomaterials technology in medical applications.

Source criticism is a tool for estimating the reliability of the data. It includes the analysis of independence, authenticity and neutrality of the sources. Primary sources are recommended because secondary sources are more prone to various influences which may have an effect on the reliability of the data. Appreciation of the research article can be evaluated according to the number of times the article was cited by other researchers. Citations to the most important recently published research articles indicate author's familiarity with the field of research. (Mäkinen 2006.)

The validity of the thesis contents was checked by emeritus professor, orthopedist Allan Aho (Department of Orthopaedic Surgery and Traumatology, Turku University Hospital and Turku Clinical Biomaterials Centre, University of Turku). Legibility and intelligibility of the text were tested with a reader who is not familiar with technical or medical terminology.

Hoitonetti web pages for the health care professionals are implemented in co-operation with Turku University of Applied Sciences in Salo, Salo Health Centre, Salo Regional Hospital and Halikko Hospital. The permission to publish an introduction and a link for this thesis in Hoitonetti is presented in Appendix 1.

This thesis contains information about the most common conventional materials used in primary hip and knee replacements nowadays. One of the major limitations of this thesis is the exclusion of novel materials (e.g. composite materials with tailor-made mechanical properties) and innovations in biomaterials technology. However, these new materials are still under development and not yet ready for widespread clinical use.

12 DISCUSSION AND CONCLUSION

A proper function of joints is essential for person's health, well-being, ability to function and the quality of life. Osteoarthritis as a progressive and degenerative joint disease is one of the major public health problems in Finland. Osteoarthritis causes not only articular cartilage degradation but has also deleterious effects in the adjacent bone and other joint tissues. Osteoarthritis of hip and knee joints is a highly disabling condition due to the pain and stiffness in the affected joint.

There is no curative treatment for osteoarthritis. The primary management and care of osteoarthritis is always conservative including patient education, weight loss, guided physical exercise and pharmacological methods for pain relief. Joint replacement surgery, i.e. replacement of the diseased articular surface with a synthetic material, may be considered if severe joint pain due to osteoarthritis is refractory to conservative treatments. Joint replacements are very efficacious orthopedic reconstructive procedures in achieving the goal of pain free mobility. However, the optimal performance of natural joints can not be achieved with man-made implants.

There are several factors affecting the outcomes of hip and knee joint replacements. The factors can be divided roughly in three categories: surgical (e.g. patient selection for the procedure, surgical technique and alignment of the joint replacement components), prosthetic (e.g. material properties, implant design, fixation methods) and patient related factors (e.g. bone quality, over-weight, activity, the pre-operative physical, mental and medical condition of the patient).

Measuring the outcomes after joint replacement requires assessment of health status pre- and post-operatively. Health status of the patient can be divided in four aspects: symptoms, quality of life, impairment and disability. Symptoms and quality of life are subjective measures and can be assessed only by patients. Disability, i.e. person's ability to function, can be assessed by both patients and clinicians. Impairment is more objective measure and can be

assessed only by clinicians according to observations and measurements of physiological function. Several instruments or measures have been developed in order to gain data about joint replacement surgery outcomes, such as Oxford Hip Score (OHS), Oxford Knee Score (OKS), Charnley Hip Score, Harris Hip Score, American Knee Society Score (AKSS), Western Ontario and McMaster Osteoarthritis Index (Womac). (Bream & Black 2009.)

The importance of pre- and post-operative patient education should not be underestimated. Oral and written patient education is an integral part of health care work. Act on the patient's status and rights obligates to give each patient enough relevant information, so that patients are able to participate in the decision-making process concerning the treatments (Laki potilaan asemasta ja oikeuksista 17.8.1992/785). Pre-operative patient education can be given by an endoprothesis nurse who is specialized in counseling, treatment, rehabilitation and follow-up of joint replacement patients. Pre-operative meeting with the endoprosthesis nurse usually covers several important topics such as patient care plan at the hospital, pre- and post-operative mobility exercises, complication prevention (e.g. infection control measures, prevention of thrombosis and prosthesis dislocation), fear and anxiety issues related to joint replacement surgery and recovery, pain management, living conditions and preparations for homecoming after surgery, activity restrictions, physiotherapy and assistive devices after surgery.

Hip and knee replacements are major surgeries which can cause both physical and psychological stress for patients. Patients' expectations concerning joint replacements usually derive from many different sources, such as from interactions with the health care providers, from patients' social networks and from research conducted by the patients themselves. The health-care providers should help the patients to develop realistic expectations about the impact of joint replacements in order to avoid negative patient outcomes after surgery.

Advances in materials technology, implant design and surgical procedures have improved outcomes after total joint replacements over the past decades. Having and maintaining advanced up-to-date knowledge about common disorders of the musculo-skeletal system, surgical procedures and modern joint replacement technology is essential to an orthopedic nurse. This thesis contains a basic information package for nurses about the current hip and knee replacement technologies with the special focus on benefits and risk factors related to implant materials and fixation methods.

REFERENCES

Aesculap Implant Systems 2012. http://www.soactivesofast.com/default.aspx?pageid=2133. Consulted 9.4.2012.

American Academy of Orthopaedic Surgeons 2012. http://orthoinfo.aaos.org/topic.cfm?topic=a00221. Consulted 9.4.2012.

An, Y.H. & Draughn, R.A. (ed.) 2000. Mechanical testing of bone and the bone-implant interface. Boca Raton: CRC Press LLC.

Baker, P.N.; van der Meulen, J.H.; Lewsey, J. & Gregg, P.J. 2007. The role of pain and function in determining patient satisfaction after total knee replacement. Journal of Bone and Joint Surgery Vol.89-Br No.7/2007, 893-900.

Bauer, T.W. & Schils, J. 1999. The pathology of total joint arthoplasty. I: mechanisms of implant fixation. Skeletal Radiology Vol.28 No.8 /1999, 423-432.

Baumgart, F. 2000. Stiffness – an unknown world of mechanical science?. Injury Vol.31 Suppl. 2/2000, S-B14–S-B23.

Berger, R.A.; Rosenberg, A.G.; Barden, R.M.; Sheinkop, M.B.; Jacobs, J.J. & Galante, J.O. 2001. Longterm follow up of the Miller-Galante total knee replacement. Clinical Orthopaedics and Related Research Vol.388 /2001, 58-67.

Berry, D.J.; Harmisen, W.S.; Cabanela, M.E. & Money, B.E. 2002. Twenty five years survivorship of two thousand consecutive primary Charnley total hip replacements. Journal of Bone and Joint Surgery Vol.84-Am No.2/2002, 171-177.

BME/ME 456 Biomechanics 2012. Biomechanics of artificial joints http://www.engin.umich.edu/class/bme456/artjoint/artjoint.htm. Consulted 9.4.2012.

Bobyn, J.D.; Pilliar, R.M.; Cameron, H.U. & Weatherly, G.C. 1980. The optimum pore size for the fixation of porous-surfaced metal implants by the ingrowth of bone. Clinical Orthopaedics and Related Research Vol.150 /1980, 263-270.

Bohm, E.R.; Dunbar, M.J.; Frood, J.J.; Jofnson, T.M. & Morris, K.A. 2012. Rehospitalization, early revisions, infections, and hospital resource use in the first year after hip and knee arthoplasties. The Journal of Arthoplasty Vol.27 No.2/2012, 232-237.

Bojescul JA, Xenos JS, Callaghan JJ, Savory CG. 2003. Results of porous-coated anatomic total hip arthroplasty without cement at fifteen years; a concise follow-up of a previous report. Journal of Bone and Joint Surgery Vol.85-Am No.6/2003, 1079–1083.

Bream, E. & Black, N. 2009. What is the relationship between patients' and clinicians' reports of the outcomes of elective surgery? Journal of Health Services Research & Policy Vol.14 No.3/2009, 174-182.

Callaghan, J.J.; Bracha, P.; Liu, S.S.; Piyaworakkum, S. Goetz, D.D. & Johnston, R.C. 2009. Survivorship of Charnley total hip arthroplasty, a concise follow-up at a minimum of 35 years. Journal of Bone and Joint Surgery Vol.91-Am No.11/2009, 2617-2621.

Campbell, D.; Mercer, G.; Nilsson, K.G.; Wells, V.; Field, J.R. & Stuart A. Callary, S.A. 2011. Early migration characteristics of a hydroxyapatite-coated femoral stem: an RSA study. International Orthopaedics Vol.35 No.4/2011, 483–488.

De Haan, R.; Campbell, P.A.; Su, E.P. & De Smet, K.A. 2008. Revision of metal-on-metal resurfacing arthroplasty of the hip: the influence of malpositioning of the components. Journal of Bone and Joint Surgery Vol.90-Br No.9/2008, 1158-1163.

Deirmengian, C.A. & Lonner, J.H. 2010. What's new in adult reconstructive knee surgery. Journal of Bone and Joint Surgery Vol.92 No.12/2010, 2753-2764.

Edwin P. 2012. Arthritis of the knee - Total knee replacement (arthroplasty) and other treatments at HSS. Hospital for Special Surgery. http://www.hss.edu/conditions_arthritis-knee-total-knee-replacement.asp. Consulted 9.4.2012.

Felson, D.T.; Zhang, Y.; Anthony, J.M.; Naimark, A. & Anderson, J.J. 1992. Weight loss reduces the risk for symptomatic knee osteoarthritis in women. The Framinghan Study. Ann Intern Med Vol.116 No.7/1992, 535-539.

Finnish Centre for Pensions and The Social Insurance Institution of Finland 2011. Statistical yearbook of pensioners in Finland (2010). Helsinki: Hakapaino Oy.

Fortin, P.R.; Penrod, J.R.; Clarke, A.E.; St-Pierre, Y.; Joseph, L.; Be´lisle, P.; Liang, M.H.; Ferland, D.; Phillips, C.B.; Mahomed, N.; Tanzer, M.; Sledge, C.; Fossel, A.H. & Katz, J.N. 2002. Timing of total joint replacement affects clinical outcomes among patients with osteoarthritis of the hip or knee. Arthritis & Rheumatism Vol.46 No.12/2002, 3327-3330.

Frind, M. & SMG Medical Graphics 2011. On-line knee library. http://factotem.org/library/database/Knee-Articles/Knee-anatomy-physiology.shtml. Consulted 9.4.2012.

Gastmeier, P.; Sohr, D.; Brandt, C.; Eckmanns, T.; Behnke, M. & Rüden, H. 2005. Reduction of orthopaedic wound infections in 21 hospitals. Archieves of Orthopaedic and Trauma Surgery Vol.125 No.8/2005, 526-530.

Gonzalez Sáenz de Tejada, M.; Escobar, A.; Herrera, C.; García, L.; Aizpuru, F. & Sarasqueta, C. 2010. Patient expectations and health-related quality of life outcomes following total joint replacement. International Society for Pharmacoeconomics and Outcomes Research Vol.13 No.4/2010, 447–454.

Grad, S.; Eglin, D; Alini, M. & Stoddart, M.J. 2011. Physical Stimulation of Chondrogenic Cells In Vitro: A Review. Clinical Orthopaedics and Related Research Vol.469 No.10/2011, 2764-2772.

Halonen, P. 2010. Lonkan pinnoitustekonivel. Niveltieto 2/2010, 24-25.

Hannouche, D.; Zaoui, A.; Zadegan, F.; Sedel, L. & Nizard, R. 2011. Thirty years of experience with alumina-on-alumina bearings in total hip arthroplasty. International Orthopaedics Vol.35 No.2/2011, 207-213.

Healthwise 2012. http://www.health.com/health/library/mdp/0,,tp10177,00.html. Consulted 9.4.2012.

Heimke, G.; Leyen, S. & Willmann, G. 2002. Knee arthoplasty: recently developed ceramics offer new solutions. Biomaterials Vol.23 No.7/2002, 1539-1551.

Huiskes, R. & Nunamaker, D. 1984. Local stress and bone adaptation around orthopaedic implants. Calcified tissue International Vol.36 Suppl.1/1984, S110-117.

Huiskes, R.; Ruimerman, R.; van Lenthe, G.H. & Janssen, J.D. 2000. Effects of mechanical forces on maintenance and adaptation of form in trabecular bone. Nature Vol.405 No.6787/2000, 704-706.

Isaac, G.H.; Brocket, C.; Breckon, A.; van der Jagt, D.; Williams, S.; Hardaker, C.; Fisher, J. & Schepers, A. J. 2009. Ceramic-on-metal bearings in total hip replacement: whole blood metal ion levels and analysis of retrieved components. Bone and Joint Surgery Vol.91-Br No.9/2009, 1134-1341.

Jacobsen, S. & Sonne-Holm S. 2005. Hip dysplasia: a significant risk factor for the development of hip osteoarthritis. A cross-sectional survey. Rheumatology Vol.44 No.2, 211-218.

Kaila-Kangas, L. (ed.) 2007. Musculoskeletal disorders and diseases in Finland. Results of the Health 2000 Survey. Helsinki: Publications of National Public Health Institute B25/2007.

Keating, E.M.; Meding, J.B.; Faris, P.M. & Ritter MA. 2002. Long-term follow up of nonmodular total knee replacements. Clinical Orthopaedics and Related Research Vol.404 /2002, 34-39.

Kishida, Y.; Sugano, N.; Sakai, T.; Nishii, T.; Haraguchi, K.; Ohzono, K. & Yoshikawa, H. 2001. Full weight-bearing after cementless total hip arthroplasty. International Orthopaedics Vol.25 No.1/2001, 25-28.

Konttinen, Y.T. & Santavirta S. (ed.) 1999. Ortopediassa ja traumatologiassa käytetyt biomateriaalit. Lääkelaitoksen biomateriaalijulkaisut.

Kärrholm, J.; Gill, R.H.S. & Valstar, E.R. 2006. The history and future of radiostereometric analysis. Clinical Orthopaedics and Related Research Vol. 448 /2006, 10-21.

Laki potilaan asemasta ja oikeuksista 17.8.1992/785.

Lombardi, A.V., Berasi, C.C & Berend, K.R. 2007. Evolution of tibial fixation in total knee arthoplasty. Journal of Arthoplasty Vol.22 No.4 Suppl 1/2007, 25-29.

Markmiller, M.; Weiß, T.; Kreuz, P.; Rüter, A. & Konrad, G. 2011. Partial weightbearing is not necessary after cementless total hip arthroplasty. A two-year prospective randomized study on 100 patients. International Orthopaedics Vol.35 No.8/2011,1139-1143.

McMinn, D.J.W.; Daniel, J.; Ziaee, H. & Pradhan, C. 2011. Indications and results of hip resurfacing. International Orthopaedics Vol.35 No.2/2011, 231-237.

Matthews, P.C.; Berendt, A.R.; McNally, M.A. & Byren, I. 2009. Diagnosis and management of prosthetic joint infection. BMJ Vol.338 No.1773/2009, 1378-1383.

Meek, R.M.; Allan, D.B.; McPhillips, G.; Kerr, L & Howie, C.R. 2006. Epidemiology of dislocation after total hip arthroplasty. Clinical Orthopaedics and Related Research Vol.447 /2006, 9-18.

Mäkelä K. 2007. Lonkan tekonivelmallit. Niveltieto 2/2007, 14-15.

Mäkelä K. 2010. Primary total hip arthroplasty for primary osteoarthritis in Finland – A national register based analysis. Academic dissertation. Helsinki: Helsinki University Print.

Mäkinen, O. 2006. Tutkimusetiikan ABC. Helsinki: Kustannusosakeyhtiö Tammi.

Naal, F.D; Pilz, R.; Munzinger, U.; Hersche, O. & Leunig, M. 2011. High Revision Rate at 5 Years after Hip Resurfacing with the Durom Implant. Clinical Orthopaedics and Related Research 469 No.9/2011, 2598-2604.

Oral, E. & Muratoglu, O.K. 2010. Vitamin E diffused, highly crosslinked UHMWPE: a review. International Ortopaedics Vo.35 No.2/2010, 215-223.

Osteoarthritis 2012. http://knol.google.com/k/osteoarthritis#. Consulted 9.4.2012.

Park, J. & Lakes, R.S. 2007. Biomaterials. An introduction. Chapter 10. Tissue response to implants. 3rd Edition. New York: Spinger Science + Business Media, LCC.

Parvizi, J.; Holiday, A.D.; Ereth, M.H. & Lewallen, D.G. 1999. Sudden death during primary hip arthropalsty. Clinical Orthopaedics Vol.369 /1999, 39-48.

Perälä, A. 2011. Lonkka- ja polviproteesit Suomessa 2010. Helsinki: Terveyden ja Hyvinvoinnin Laitos.

Phillips, J.E.; Crane, T.P.; Noy, M.; Elliott, T.S. & Grimer, R.J. 2006. The incidence of deep prosthetic infections in a specialist orthopaedic hospital: a 15-year prospective survey. Journal of Bone and Joint Surgery Vol.88-Br No.7/2006, 943-948.

Pluot, E.; Davis, E.T.; Revell, M.; Davies, A.M. & James, S.L.J. 2009. Hip arthoplasty. Part 1: prosthesis terminology and classification. Clinical Radiology Vol.64 No.10/2009, 954-960.

Polvi- ja lonkkanivelrikon Käypä hoito –suositus 2007. Duodecim Vol.123 No.5/2007, 602-620 and www.käypähoito.fi

Radl, R.; Aigner, C.; Hungerford, M.; Pascher, A. & Windhager, R. 2000. Proximal femoral bone loss and increased rate of fracture with a proximally hydroxyapatite-coated femoral component. Journal of Bone and Joint Surgery Vol.82-Br No.8/2000, 1151-1155.

Rajaratnam, S.S.; Jack, C.; Tavakkolizadeh, A.; George, M.D.; Fletcher, R.J.; Hankins, M. & Shepperd, J.A.N. 2008. Long-term results of a hydroxyapatite coated femoral component in total hip replacement: A 15- to 21-year follow-up study. Journal of Bone and Joint Surgery Vol.90-Br No.1/2008, 27-30.

Rand, J.A. & Dorr, L. (ed.) 1986. Total Arthoplasty of the knee. Chapter: Fixation in total knee arthoplasty. Proceedings of the Knee Society 1985-1986. Rockville: Aspen Publishers.

Revell, P.A. (ed.) 2008. Joint replacement technology. Cambridge, UK: Woodhead Publishing Limited.

Rolfson, O.; Dahlberg, L.E.; Nilsson, J.-Å.; Malchau, H. & Garellick, G. 2009. Variables determining outcome in total hip replacement surgery. Journal of Bone and Joint Surgery Vol.91-B No.2/2009, 157-161.

Sanfilippo, J.A. & Austin, M.S. 2006. Implants for total hip arthoplasty. Expert Review of Medical Devices Vol.3 No.6/2006, 769-776.

Semlitsch, M. & Willert, H.G. 1997. Clinical wear behaviour of ultra-high molecular weight polyethylene cups paired with metal and ceramic ball heads in comparison to metal-on-metal pairings of hip joint replacements. Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine Vol. 211 No.1/1997, 73-88.

Senthi, S.; Munro, J.M. & Pitto, R.P. 2011. Infection in early total hip replacement: meta-analysis. Internation Orthopaedics Vol.35 No.2/2011, 253-260.

Southern California Orthopedic Institute 2012. Anatomy of the hip. http://www.scoi.com/hip.htm. Consulted 9.4.2012.

Søballe, K,; Hansen, E.S. & Rassmussen, H.B.; Jorgensen, P.H.; Bunger, C. 1992. Tissue ingrowth into titanium and hydroxyapatite-coated implants during stable and unstable mechanical conditions. Journal of Orthopaedic Research Vol.10 /1992, 285-299.

Sun, H.B. 2010. Mechanical loading, cartilage degradation, and arthritis. Annals of the New York Academy of Sciences Vol.1211 No.1/2010, 37-50.

Sundfeldt, M.; Carlsson, L.V.; Johansson, C.B.; Thomsen, P. & Gretzer, C. 2006. Aseptic loosening, not only a question of wear: A review of different theories. Acta Orthopaedica Vol.77 No.2/2006, 177-197.

SurfaceHippy Hip Resurfacing 2012. http://www.surfacehippyinfo.com/devices/sn-bhr/. Consulted 9.4.2012.

Tannast, M.; Goricki, D.; Beck, M.; Murphy, S.B. & Siebenrock, K.A. 2008. Hip damage occurs at the zone of femoroacetabular impingement. Clinical Orthopaedics and Related Research Vol.466 /2008, 273-280.

Teloken, M.A.; Bissett, G.; Hozack, W.J.; Sharkey, P.F. & Rothman, R.H. 2002. Ten to fifteen-year follow-up after total hip arthroplasty with a tapered cobalt chromium femoral component (Tri-Lock) inserted without cement. Journal of Bone and Joint Surgery Vol.84-Am No.12/2002, 2140-2144.

The hip 2000. Acta Orthopaedica Scandinavia Vol.71 No.S294/2000, 57-64.

The knee 2000. Acta Orthopaedica Scandinavia Vol.71 No.S294/2000, 65-75.

The McMinn Centre. UK 2012. http://www.mcminncentre.co.uk/birmingham-hip-resurfacing.html#. Consulted 9.4.2012.

Tolksvig-Larsen, S.; Franzen. H. & Ryd. L. 1991. Cement interface temperature in hip arthroplasty. Acta Orthopaedica Scandinavia Vol.62 No.2/1991 102-105.

Triclot, P. 2011. Metal-on-metal: history, state of art (2010). International Ortopaedics Vol.35 No.2/2010, 201-206.

Tri State Orthopaedics & Physical Therapy 2012. http://www.tri-stateorthopaedics.com/total-hip-joint.html. Consulted 9.4.2012.

Tules – kivuliasta ja kallista. Available at: http://www.tules-vuosikymmen.org/tules/tules.html. Consulted 15.5.2011.

Törmälä, P. 2001. Yleiskatsaus terveydenhuollon laitteissa ja tarvikkeissa käytettyihin biomateriaaleihin. Lääkelaitoksen biomateriaalijulkaisut.

Vainikainen, T. 2010. Nivelkirja: nivelrikon ehkäisy, tekoniveleleikkaus ja kuntoutuminen. Helsinki: WSOY.

VanPutte, C.; Regan, J. & Russo, A. 2010. Seeley's essentials of anatomy and physiology. 7th Edition. New York: The McGraw-Hill Companies Inc.

Vidalain, J.-P. 2011. Twenty-year results of the cementless Corail stem. International Orthopaedics Vol.35 No.2/2011, 189-194.

von Knoch, M.; Berry, D.J.; Harmsen, W.S. & Morrey, B.F. 2002. Late dislocation after total hip arthroplasty. Journal of Bone and Joint Surgery Vol.84-Am No.11/2002, 1949-1953.

Vrahas, M.S.; Mithoefer, K & Joseph, D. 2004. The long-term effects of articular impaction. Clinical Orthopaedics and Related Research Vol.423 /2004, 40-43.

Webb, J.C.J & Spencer, R.F. 2007. The role of polymethylmethacrylate bone cement in modern orthopaedic surgery. Journal of Bone and Joint Surgery Vol. 89-Br No.7/2007, 851-857.

Williams, D.F. 1999. The Williams dictionary of biomaterials. Liverpool, UK: Liverpool University Press.

Wylde V.; Dieppe, P.; Hewlett, S. & Learmonth, I.D. 2007. Total knee replacement: Is it really an effective procedure for all? The Knee Vol.14 No.6/2007, 417-423.

Zhang, Y. & Jordan, J.M. 2010. Epidemiology of osteoarthritis. Clinical Geriatric Medicine Vol.26 No.3/2010, 355-369.

MANDATES

TURUN AMMATTIKORKEAKOULU
TURKU UNIVERSITY OF APPLIED SCIENCES

OPINNÄYTETYÖN TOIMEKSIANTOSOPIMUS 1

OPISKELIJAN TIEDOT

Nimi: Riina Mattila
Osoite: [redacted]
Puhelin koti: [redacted] Puhelin työ:
Sähköposti: riina.mattila@utu.fi
Koulutusohjelma: Degree Programme in Nursing

OPINNÄYTETYÖ

Aihe/ työnimi: Lonkan ja polven tekoniveltietoa potilaalle
Aikataulu: 1.6. - 30.9.2011

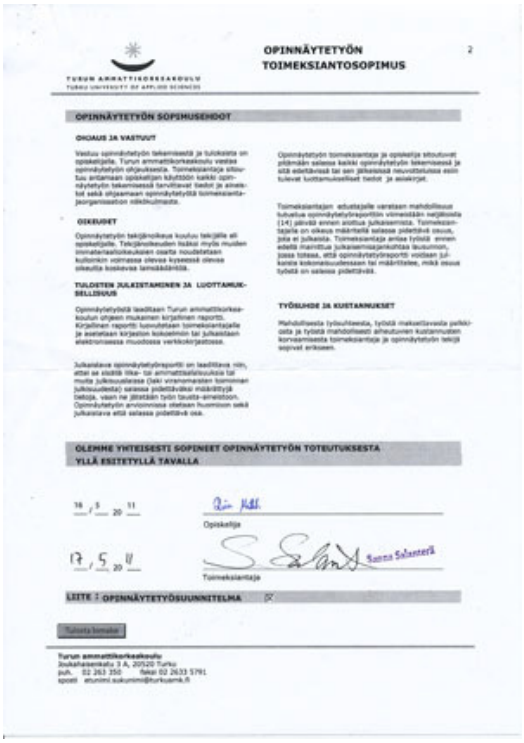
TOIMEKSIANTAJA

Organisaatio: Turun yliopisto, Hoitotieteen laitos
Työn ohjaaja / yhteyshenkilö: Prof. Sanna Salanterä
Osoite: Lemminkäisenkatu 1, 20014 Turun yliopisto
Puhelin: 333 8414 Sähköposti: sanna.salantera@utu.fi

OHJAAVAN OPETTAJAN YHTEYSTIEDOT

Ohjaava opettaja: Heikki Ellilä
Puhelin: 044-907 5489 Sähköposti: heikki.ellila@turkuamk.fi

Turun ammattikorkeakoulu
Joukahaisenkatu 3 A, 20520 Turku
puh. 02 263 350 faksi 02 2633 5791
sposti etunimi.sukunimi@turkuamk.fi



TURUN AMMATTIKORKEAKOULU
TURKU UNIVERSITY OF APPLIED SCIENCES

OPINNÄYTETYÖN TOIMEKSIANTOSOPIMUS 2

OPINNÄYTETYÖN SOPIMUSEHDOT

OHJAUS JA VASTUUT

Vastuu opinnäytetyön tekemisestä ja tuloksista on opiskelijalla. Turun ammattikorkeakoulu vastaa opinnäytetyön ohjauksesta. Toimeksiantaja sitoutuu antamaan opiskelijan käyttöön kaikki opinnäytetyön tekemisessä tarvittavat tiedot ja aineistot sekä ohjaamaan opinnäytetyötä toimeksiantajaorganisaation näkökulmasta.

OIKEUDET

Opinnäytetyön tekijänoikeus kuuluu tekijälle eli opiskelijalle. Tekijänoikeuden lisäksi myös muiden immateriaalioikeuksien osalta noudatetaan kulloinkin voimassa olevaa kyseessä olevaa oikeutta koskevaa lainsäädäntöä.

TULOSTEEN JULKAISTAMINEN JA LUOTTAMUKSELLISUUS

Opinnäytetyöstä laadittaan Turun ammattikorkeakoulun ohjeen mukainen kirjallinen raportti. Kirjallinen raportti luovutetaan toimeksiantajalle ja asetetaan kirjaston kokoelmiin tai julkaistaan elektronisessa muodossa verkkokirjastossa.

Julkaistava opinnäytetyöraportti on laadittava niin, ettei se sisällä liike- tai ammattisalaisuuksia tai muita julkisuuslaissa (laki viranomaisten toiminnan julkisuudesta) salassa pidettäviksi määrättyjä tietoja, vaan ne jäävätään työn tausta-aineistoon. Opinnäytetyön arvioinnissa otetaan huomioon sekä julkaistava että salassa pidettävä osa.

Opinnäytetyön toimeksiantaja ja opiskelija sitoutuvat pitämään salassa kaikki opinnäytetyön tekemisessä ja sitä edeltävissä tai sen jälkeisissä neuvottelussa esiin tulevat luottamukselliset tiedot ja asiakirjat.

Toimeksiantajan edustajalle varataan mahdollisuus tutustua opinnäytetyöraporttiin viimeistään neljässä (14) päivää ennen aiottua julkaisemista. Toimeksiantajalla on oikeus määritellä salassa pidettävä osuus, joka ei julkaista. Toimeksiantaja antaa työstä ennen edellä mainittua julkaisemisajankohtaa lausunnon, jossa todetaan, että opinnäytetyöraportti voidaan julkaista kokonaisuudessaan tai määrittelee, mikä osuus työstä on salassa pidettävää.

TYÖSUHDE JA KUSTANNUKSET

Mahdollisesta työsuhteesta, työstä maksettavasta palkkiosta ja työstä mahdollisesti aiheutuvien kustannusten korvaamisesta toimeksiantaja ja opinnäytetyön tekijä sopivat erikseen.

OLEMME YHTEISESTI SOPINEET OPINNÄYTETYÖN TOTEUTUKSESTA YLLÄ ESITETYLLÄ TAVALLA

16 / 5 20 11 Riina Mattila
Opiskelija

17 / 5 20 11 Sanna Salanterä
Toimeksiantaja

LIITE 1 OPINNÄYTETYÖSUUNNITELMA

Tulosta lomake

Turun ammattikorkeakoulu
Joukahaisenkatu 3 A, 20520 Turku
puh. 02 263 350 faksi 02 2633 5791
sposti etunimi.sukunimi@turkuamk.fi

TURUN AMMATTIKORKEAKOULU
Terveysala, Salo
Ylhäistentie 2
24130 SALO
Puh. (02) 263 350
Fax. (02) 2633 6179

ANOMUS OPINNÄYTETYÖN AINEISTON KOKOAMISEKSI

Tutkimuksen nimi	The hip and knee replacement implants – Information package for nurses
Tutkimusongelma	Kerätä tietopaketti lonkka- ja polviproteesien hyödyistä ja ongelmista hoitohenkilökunnalle Hoitonettiin
Tutkimuksen kohde ja aineiston keruumenetelmä	Kirjallisuuskatsaus
Aineiston kokoamisajankohta	Kesäkuu - Syyskuu 2011
Tutkimuksen arvioitu valmistumisajankohta	Tammikuu 2012
Tutkimussuunnitelma hyväksytty	24/10 2011
Tutkimuksen ohjaajat	Heikki Ellilä puh 044 907 5489 Tiina Pelander puh 044 907 5486

Sitoudumme käyttämään kokoamaamme aineistoa tutkimusongelman puitteissa ja siten, että tutkimuksen kohteena olevien henkilöiden anonymiteetti säilyy.

Tutkimuksen tekijät Degree programme in nursing / SNUS09
(suuntautumisvaihtoehto) (ryhmä)

Riina Mattila
(nimi)

[redacted]
(osoite)

[redacted]
(puhelinnumero)

Anomus käsitelty 31/10 2011
(X) lupa myönnetty
( ) lupa evätty, peruste _____

Allekirjoitus _____ Seija Hyvärinen
Hallintoylihoitaja
Salon terveyskeskus

Anomus ja tutkimussuunnitelma toimitetaan yhtenä kappaleena, josta toimeksiantaja lähettää kopiot yhdelle opiskelijalle, yhdelle ohjaavalle opettajalle ja kullekin työhön osallistuvalle toimipisteelle. Alkuperäinen jää toimeksiantajalla. Valmis työ toimitetaan toimeksiantajalle sovitulla tavalla.