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Diabetic Leg Ulcers

Prevention and treatment

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Abstract

Diabetic leg ulcers are a major complication of diabetes, and are one of the leading causes of hospitalization for diabetic patients. Diabetic foot ulcers often require specialized treatment and their prevention requires early, acute detection and intervention. The information regarding these issues can be varying and fragmented between many differing sources, possibly leading to different approaches to diabetic foot care between locations.

The aim of this study was to find effective methods of prevention and treatment for diabetic foot ulcers. The purpose was to compile this information, and offer it in an easy to find, approach and read format for nurses and nursing students.

A literature review through electronic databases search of Cinahl and Pubmed was performed. Included were full, recent (years 2010-2016) and diverse articles. Total number of articles reviewed were 16. The data analysis was conducted as content analysis.

Varying methods for both treatment and prevention were found as a result of the review, ranging from patient guidance and regular check-ups to surgical intervention Their effectiveness varies, requiring careful contemplation on a case-to-case basis. Often multiple different methods are required to be used in combination for effective treatment and prevention of an ulcer.

Keywords/tags (subjects)
Diabetic leg ulcer, treatment, prevention, wound care, diabetes

Miscellaneous

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1 Introduction

Diabetic chronic wounds often cause the patient unnecessary suffering and prolonging of treatment, and also causing increased costs for society. The treatment of a chronic wound can take months. Most of the costs of all chronic wound care come from hospital treatment periods, wages of the staff included in the care and the time taken by the care, with very little actually caused by the price of wound care products (Niemi, 2015). In Helsinki alone, chronic wounds cost approximately 7-14 million euros annually. The national costs are difficult to calculate, since local guidelines vary, so only estimates can be given. (Korhonen & Lepäntalo 2012, 1.) In her interview for Aamuset (2015), Niemi states that the costs nationally are most likely in the range of several hundred millions.

Approximately 15-25% of diabetics suffer from a leg wound during their lifetime. Of those, approximately 5-8% have had amputation done within a year of the wounds appearance. Infections of leg wounds are the leading cause of hospitalization of all the diabetes complications. (Juutilainen & Hietanen 2012, 338.) In 1997, the total costs of diabetes care in Helsinki were approximately 433,6 million Finnish marks, so approximately 72,3 million euros. Of these costs, approximately 67% were due to complications of diabetes, including diabetic wounds. (Kangas 2002, 116.) Information and easy to access guidelines for the treatment and prevention of diabetic leg ulcers could help bring the costs of diabetic care down, and also improve the quality of diabetic foot care in areas where specialized care might not be easily accessible.

2 Chronic wounds

2.1 Diabetic chronic wounds

A wound is when the skin and/or the tissue layers underneath it is damaged due to an external or internal factor, or a combination of them both. In English literature,

the word wound is often associated with an acute wound, while the word ulcer ties with a wound that has become chronic. (Juutilainen & Hietanen 2012, 26.)

Wounds traditionally categorized as chronic are those associated with prolonged healing times (Flanagan 1997, 38). In a chronic wound, the inflammation stage is prolonged by, for example, large amounts of dead tissue, foreign bodies or bacteria. This prolonged inflammation stage delays the proliferation stage (Juutilainen & Hietanen 2012, 51). The activity of growth factors is weaker than normal. The effect of proliferation is weak, because collagen and other substances are broken down by the excess amount of defensive cells left by a prolonged inflammation stage. (Juutilainen & Hietanen 2012, 52.)

A wound is often considered chronic after it has been open for a month. This definition is however very artificial, because many acute wounds can require the same time to heal (Juutilainen & Hietanen 2012, 26). Juutilainen and Hietanen thus propose in their book that it would be more consistent to classify as chronic wounds those that are caused by some inner factor possibly in conjunction with an outer factor. Such factors would typically be for example diabetes, cancer, atherosclerosis or constant pressure or friction. They propose that it would be wise to classify for example pressure ulcers or diabetic leg ulcers as chronic wounds straight away, instead of waiting for the artificial one month limit. The healing process of a wound can be interrupted or delayed for many reasons often separated into systemic or local factors.

Diabetic leg wounds are wounds most often found in the ankle, toes or foot area of the leg. These wounds are often brought about by a combination of decreased circulation, neuropathy and infection of some degree. Wounds in the shin area are most often related to angiopathy, vasculitis or other cardiovascular co-morbidity of diabetes. (Juutilainen & Hietanen 2012, 338; Flanagan 1997, 105-106.) Different forms of neuropathy make a diabetic susceptible to leg wounds in different ways. Sensory

nerve damage causes the loss of feelings of pain and touch, making it difficult to notice for example chafing from a shoe. Motor nerve damage changes the posture of the foot, for example making the toes curl more making it easier for callus to form or for chafing to happen. Autonomic nervous system damage leads to less perspiration, and drying and cracking of the skin. (Juutilainen & Hietanen 2012, 340; Flanagan 1997, 107.) High blood glucose levels decrease the effectiveness of the immune system, leading to a higher risk of infection of even small wounds (Juutilainen & Hietanen 2012, 339).

2.2 Stages of wound healing

The healing process of a wound is a complicated process, which relies on the conditions of the wound, the local tissue surrounding it and systemic conditions (Juutilainen & Hietanen 2012, 29). The process of wound healing can be divided into three or four phases, depending if the first phase, hemostasis, is considered its own phase or not, as some works include it as part of the inflammation phase. The four steps are: hemostasis, sometimes also called vascular response, inflammation, proliferation and maturation. (Flanagan 1997, 23.) Even though the phases of wound healing are presented as following each other, there is overlap in the time they happen, so they are not mutually exclusive (Juutilainen & Hietanen 2012, 30; Flanagan 1997, 23).

The **hemostasis** stage starts immediately after tissue damage. Damaged blood vessels constrict, and platelets along with a fibrin mesh form to block the wound and stem the bleeding. The fibrin mesh is formed and the platelets activated as part of a complex biological chain reaction known as the coagulation cascade, which involves 13 different coagulation factors. The constriction of blood vessels can last anywhere from between 5 to 20 minutes. (Flanagan 1997, 23.)

While the damaged blood vessels constrict, the blood vessels of surrounding tissue are dilated by histamine and other substances released by cell and tissue damage. The dilated blood vessels are more permeable, allowing faster blood flow and the accumulation of fluid in the soft tissue around the wound. The tissue surrounding the

wound becomes warmer, swollen and reddish in color. The wound area is uncomfortable to move, and if near a joint, the movement of the joint can be impaired. This **inflammation** functions as the body's warning system to prevent movement of the wound, allowing faster healing and should not be mistaken with infection, even though many of the symptoms are the same. (Hietanen et al. 2002, 28-30.) During the inflammation phase, a few hours after the birth of the wound, white blood cells start appearing in the wound area in larger numbers. Neutrophils arrive first, providing initial protection by destroying bacteria and other foreign matter (Flanagan 1997, 24). Monocytes arrive next, and as they mature into macrophages they provide many important functions for the wound, such as synthesizing and excreting growth factors like fibroblasts, break down necrotic tissue and also provide protection from foreign bodies. (Hietanen et al. 2002, 30.) The inflammatory phase cleans the wound bed, and prepares the wound for following stages of wound healing and is vital for proper wound healing (Flanagan 1997, 24). According to Flanagan, the inflammatory stage lasts approximately 36 hours; while according to Hietanen et al. the arrival of monocytes can take anywhere between 48 to 96 hours. In either case, the length of the inflammatory phase is substantially prolonged in chronic or otherwise impeded wound healing.

The third stage of wound healing is called **proliferation**. The proliferation stage itself consists of three different processes, known as granulation, contraction and epithelialization. In the granulation process, fibroblasts attracted by the growth factors released by macrophages during the inflammation phase gather at the wound site. They produce collagen fibers, forming new connective tissue at the wound site. At the same time, new capillaries start forming to replace those that were damaged and to provide proper oxygenation to the hypoxic areas of the wound. (Flanagan 1997, 24.) This newly formed and vascularized tissue that forms is called granulation tissue, and when healthy it is bright red, moist, shiny and granular, slightly uneven (Flanagan 1997, 24). When enough new connective tissue has been rebuilt, fibroblasts transform into myofibroblasts and fibrocytes. The function of myofibroblasts is to gather at the wound edges and contract, pulling the wound edges closed or at least closer to each other, decreasing the wound area. This allows for a faster healing process, since

the scar that has to be formed does not have to be as large. (Flanagan 1997, 25.) The last process of proliferation, epithelialization, is a very delicate process during which new epithelial cells grow across the surface of the wound, allowing for the growth of a scar and new skin tissue. This stage is very dependent on a good wound setting, and can be considerably delayed if there are negative factors at play. (Flanagan 1997, 25.) The growth of new epithelial cells begins at the wound edges or at hair follicles or sebaceous or sweat glands that might be left in the wound area. Epithelialization requires a healthy layer of granulation tissue underneath to be able to properly grow (Flanagan 1997, 25).

Maturation is the fourth and last stage of wound healing. It is also the stage that in a normal wound takes the longest, lasting a year or even longer (Juutilainen & Hietanen 2012, 37). The many small capillaries formed in the wound area during granulation merge into fewer but larger blood vessels. Excess macrophages and myofibroblasts die and are removed from the wound tissue, leaving behind scar tissue with little cells in it, consisting mainly of proteins and type I collagen, forming a tough substance. Granulation tissue is replaced by a mesh made of a mix of collagen and elastin, giving the tissue a much higher tensile strength. (Juutilainen & Hietanen 2012, 37.)

3 Factors influencing wound healing

3.1 Diabetes Mellitus

Diabetes mellitus is a chronic condition, in which the insulin needs of the body cannot be met. This can be caused by decreased or completely lacking production of insulin by the body, or by a built up insulin resistance. This leads to elevated blood sugar levels. (Iivanainen et al. 2012, 536.) If left untreated, diabetes is associated with large amounts of both acute and chronic risks (Välimäki et al. 2009, 729).

Diabetes is divided into two main types: type I and type II. Some sources count gestational diabetes as a separate third main type of diabetes. Gestational diabetes is a temporary onset of diabetes during pregnancy. Most cases of gestational diabetes can be treated with proper diet, but approximately 10% need insulin treatment to keep their blood glucose levels in control. (Välimäki et al. 2009, 769.) It should be noted that those who suffer from gestational diabetes have an increased risk of diabetes type II onset later in life and should be considered to be part of the risk group (Välimäki et al. 2009, 769).

Type I diabetes, often also called juvenile diabetes, is a condition where the patients pancreas produces no insulin. The beta cells that produce insulin inside the Islets of Lagerhans in the pancreas are destroyed, either due to autoimmune reaction or other idiopathic reasons. (Iivananinen et al. 2012, 544.) The onset of the disease usually happens before 30-years of age, and most often before 15-years of age. In the year 2007, it was estimated that there are 500 000 diabetics in Finland, out of which approximately 15% are type I diabetics. (Välimäki et al. 2009, 725.) Type I diabetics are always dependent on insulin treatments due to not being able to produce it on their own.

Type II diabetes, sometimes also known as adult-onset diabetes, is a type of diabetes that as the name implies, usually begins as an adult. Type II diabetes is considerably more common than type I, as approximately 75% of the diabetics in Finland are type II diabetics. (Iivanainen et al. 2012, 536.) The rise of blood glucose levels in type II diabetes can be caused by insulin resistance, or insulin secretion dysfunction (Välimäki et al. 2009, 724). The onset of type II diabetes is often tied with metabolic disorder symptoms, such as obesity, lipid imbalance and increased blood pressure. The body slowly develops insulin resistance, and up to a certain point the pancreas is able to compensate by increasing insulin excretion. At a certain point this mechanism is unable to keep up with the elevated blood glucose levels. (Iivanainen et al. 2012, 537.) In type II diabetes, the insulin secretion of the pancreas never completely stops, so if diagnosed early a type II diabetic might be able to cope quite long without insulin

treatment. Other treatments for type II treatment include non-medicinal treatments such as weight loss, exercise and proper diet. Oral tablet medications can be used to increase insulin excretion or increase insulin susceptibility of cells and to control the glucose production of the liver. (Iivanainen et al. 2012, 540.) Insulin can be used periodically to lower blood glucose levels in case of for example infections, or continuously if other treatment methods have failed to keep blood glucose levels in normal range (Iivanainen et al. 2012, 541). Genetics play a part in the onset of type II diabetes, but most cases are still mainly influenced by other risk factors. Overweight, especially in the midsection, small amounts of exercise, age, high blood pressure and vascular diseases are often related with the onset of type II diabetes. (IIvanainen et al. 2012, 537.)

Diabetes carries a risk of developing additional conditions. The risk of these conditions is related with genetics and the proper control of glucose levels. 10-15% of patients with poor glycemic control do not get additional conditions. Despite good glycemic control, there's still a 10-15% risk of good glycemic control patients also suffering from additional conditions. (Iivanainen et al. 2012, 561.) Insulin resistance furthers the obstruction of blood vessels, causing circulatory problems. With poor glycemic control, sorbitol builds up in nerve tissue, swelling it and causing nerve damage. (Iivanainen et al. 2012, 561.)

Retinopathy, or changes in the retina of the eye, are caused when high blood glucose levels damage the small blood vessels of the eye. Retinopathy leads to a decrease in eyesight and untreated will lead to blindness. Hypertension, smoking and hypercholesterolemia increase the risk of retinopathy. (Iivanainen et al. 2012, 562.)

Approximately every third type I diabetic and every fourth type II diabetic develop diabetic kidney disease, also known as nefropathy, to some degree (IIvanainen et al. 2012, 563). Nefropathy develops as the result of high blood pressure and poor glycemic control; the amount of albumin in the urine keeps increasing, further increasing

blood pressure and decreasing blood flow into the kidneys, thus decreasing the body's ability to filter out waste products and untreated can lead to kidney failure and the need for either dialysis treatment or a kidney transplant (Iivanainen et al. 2012, 563).

Neuropathy can damage the nerves of the body. The exact cause of neuropathy is still somewhat unclear, but it has been tied with poor glycemic control, damaged blood vessels, age and duration of the diabetes. Neuropathy leads to loss of feeling in the affected areas, usually the lower extremities. This lower extremity nerve damage can also cause the foot to drag, which combined with numbness can make the foot more susceptible to wounds. (Iivanainen et al. 2012, 563.) Other symptoms of neuropathy include tachycardia, urinary difficulties, impotence, heart palpitations, dizziness, nausea or diarrhea and difficulties recognizing hypoglycemia (Iivanainen et al. 2012, 563). If nerve damage has already happened, it cannot be fixed, but further damage can be prevented with proper control of blood pressure and glucose levels.

Both type I and type II diabetics are at an increased risk of suffering a stroke, or developing a cardiovascular disease. Iivanainen et al. (2012) approximate that diabetics have a 2-4 times greater chance of suffering an infarction or developing coronary artery disease, since diabetes increases the development of blockages in blood vessels. As with other types of diabetes co-morbidities, the risk can be lowered by proper glucose control and stable normal blood pressure levels of 130/80 mmHg or lower (Iivanainen et al. 2012, 564). The damage to veins is also known as angiopathy.

3.2 Systematic factors affecting wound healing

Systemic factors refer to factors related to the patient as a whole system. They often relate to the oxygenation and nutrition gain of the tissue, or to the metabolism of the tissue. Systemic factors include oxygenation, smoking, alcohol or drug use, obesity, aging, nutrition, some medications and certain diseases.

Oxygen is one of the most important systemic factors in relation to wound healing. Cells require oxygen for cell respiration, to produce energy for their function. The process of wound healing requires large amounts of energy, and without proper oxygenation, this need of energy cannot be met. (Juutilainen & Hietanen 2012, 39.) A slight hypoxia in the beginning of the wound healing process stimulates angiogenesis and the birth of fibroblasts, but as the process continues, the need for oxygen grows and hypoxia becomes detrimental (Juutilainen & Hietanen 2012, 40; Flanagan 1997, 30). Proper oxygenation helps prevent infections, as white cells operate more effectively in an oxygen rich environment. Since oxygen is toxic to anaerobic bacteria, their amount is also decreased in a properly oxygenated wound area. There are many reasons why a lack of oxygen might happen at the wound site. Pulmonary diseases such as asthma, COPD or pneumonia reduce the amount of oxygen in the blood. Cardiovascular diseases affect the flow of blood, heart failure decreasing the pumping power of the heart and atherosclerosis blocking the blood vessels, preventing proper oxygenation. Tissue edema can constrict the blood vessels on their way to the wound site. Anemia, blood cancers and myelofibrosis impair hemoglobin's capacity to carry oxygen. (Juutilainen & Hietanen 2012, 40; Flanagan 1997, 31.) Smoking ties into oxygenation. Nicotine causes blood vessel constriction, and impairs the division of macrophages, leaving the body more susceptible to infection. Carbon monoxide ties itself into hemoglobin, replacing oxygen. (Juutilainen & Hietanen 2012, 41.)

Obesity also affects wound healing in multiple ways. The functional volume of the lungs is decreased, leading to decreased oxygenation. Adipose tissue, also known as fat tissue, also has less capillaries, making wounds more prone to issues due to lack of circulation. Obesity is also often related with reduced venous return and lymph circulation problem from the lower limbs, possibly leading to edema and reduced circulation in the lower limbs. (Juutilainen & Hietanen 2012, 41; Flanagan 1997, 31.) Obesity also increases the risk of complications to surgical wounds, such as tearing of the wound. Obesity might also indicate imbalanced blood glucose levels, which also negatively affect the proper healing of a wound. (Juutilainen & Hietanen 2012, 41.)

Proper nutrition during the wound healing process is a very important, and sadly often easily overlooked factor. With large wound areas and not enough nutrition, the body can enter a catabolic state, where body tissue is broken down to meet the energy consumption of cells instead of it coming from nutrition. Proteins play an important role as building blocks for fibroblasts and collagen. Protein deficit can also lead to edema in the tissue, thus decreasing the oxygenation of the wound area. (Juutilainen & Hietanen 2012, 42; Flanagan 1997, 31.) Carbohydrates, along with fats, act as the main energy source for protein synthesis and white blood cell activity. Fatty acids work as a building block for cell walls, and omega-3 fatty acids help in infection prevention due to their anti-inflammatory effect. Vitamins and trace elements, such as zinc, iron, copper and magnesium also play their part in wound healing. Vitamin C helps support the function of the immune system and as a building block for collagen. Vitamin A stimulates the arrival of macrophages at the wound area. Vitamin K is a crucial part of the coagulation cascade as it is used in multiple coagulation factors' creation. Vitamin B is used in the protein and DNA synthesis processes. (Juutilainen & Hietanen 2012, 43.)

Diabetes is the most common disease that negatively affects wound healing. The early inflammatory response is weakened with diabetics, and hyperglycemia slows the travel of white blood cells to the wound area. When the wound area cannot be kept clean by white blood cells, the infection risk of the wound increases. (Juutilainen & Hietanen 2012, 44.) Higher blood glucose levels also interferes with the work of fibroblasts and endothelial cells. Red blood cells can also become less malleable due to high blood glucose levels, making it more difficult for them to reach smaller capillaries (Juutilainen & Hietanen 2012, 44). Other diseases that can negatively affect wound healing include, but are not limited to, the following: liver and kidney diseases, cancer, HIV, rheumatic diseases, pancreatic, stomach or small intestine diseases (Juutilainen & Hietanen 2012, 45; Flanagan 1997, 31).

Some medications can also have a detrimental effect on the wound healing process. Anticoagulants and nonsteroid anti-inflammatory drugs (NSAID) affect the early clotting of the wound. NSAIDs also reduce the synthesis of collagen by up to 45%, so their use is contraindicated in wound care. (Juutilainen & Hietanen 2012, 45; Flanagan 1997, 31.) Corticosteroids reduce the effectiveness of the inflammatory phase and impair the work of macrophages, white blood cells and collagen synthesis. They also constrict capillaries, and long-term usage can lead to thinning of the skin (Juutilainen & Hietanen 2012, 45). Cytostatic drugs impair the dividing of cells, the amount of white blood cells is decreased and infection risk is increased considerably (Juutilainen & Hietanen 2012, 46; Flanagan 1997, 31).

3.3 Local factors affecting wound healing

Local factors refer to things inside the wound and in its immediate vicinity. These factors include things like infection, temperature and moisture level of the wound, ischemia and of course the size and location of the wound. Some of these factors can be affected by wound cleansing and the proper choice of wound dressing, helping optimize the healing process of the wound. (Flanagan 1997, 27.)

A balanced moisture level of the wound has been proven to positively affect the healing process. The wound exudate excreted during the inflammation phase is slightly acidic, helping defend against infection, while also including growth factors and nutrients beneficent to the wound healing process. (Juutilainen & Hietanen 2012, 48; Flanagan 1997, 27-28.) The re-epithelialization of the wound, growth of granulation tissue and the travel of cells is positively affected by a proper moisture level. If the moisture level of a wound is too high, the tissue surrounding the wound can become macerated, separating the layers of skin from each other. In this state, contraction of the wound or epithelialization cannot happen. Macerated tissue is also soft and vulnerable to damage and infection. (Juutilainen & Hietanen 2012, 48; Flanagan 1997, 30.) In a dry wound setting, the movement of cells is slowed and cells are dried out and killed.

The temperature of the wound should remain as close to normal body temperature as possible. Low temperature in the wound area causes cell division, granulation tissue growth and epithelialization to slow down or stop. In a cold environment, oxygen has problems to detach from hemoglobin, causing impaired oxygenation. (Juutilainen & Hietanen 2012, 48; Flanagan 1997, 27 & 30.)

The location of the wound can dramatically affect the healing process. The amount of capillaries is lower in the lower extremities, making circulation slower. The lower extremities are also more susceptible to swelling due to tissue damage than the upper extremities for example. Movement, either due to a nearby joint or musculature, can also irritate the wound. (Juutilainen & Hietanen 2012, 49; Flanagan 1997, 30.)

4 Aims and purpose

The aim of this thesis is to provide an easy to access and condensed information source about diabetic chronic wounds to nursing students and the purpose is to provide information that can be used in the prevention and treatment of diabetic chronic wounds. This literature review aims to answer the following research question:

- What nursing methods are effective to prevent and treat diabetic leg wounds based on existing literature?

5 Methodology

5.1 Literature review

When literature of a specific topic is broadly studied and analyzed, it is called literature review (Aveyard 2010, 5-6; Cronin, Ryan & Coughlan 2008, 38; Saks & Allsop 2007, 33). Literature review helps to understand the facts and knowledge of the topic.

There are possible gaps in the information, in this case in diabetic leg wound prevention and treatment, and thus the literature review try to recognize these. (Saks & Allsop 2007, 33.) Commonly when conducting a research, there should be one to three research questions that are as explicit as possible, and in this case only one (Oxman 1994; Cook, Murlow, Haynes 1997; Meade & Richardson 1997). After the precise research question(s) it is time to choose methods for the literature review. The methods include the specific search terms and the information sources used (Greener & Grimshaw 1996; Khan, Kunz, Kleijnen & Antes 2003). According to Aveyard (2010) literature review is putting together as much literature of one topic available as possible. With the help of the research question the literature review can be specific and on-point of the subject at hand thus giving more understanding to it. In conclusion, when the literature review is comprehensive, reliable, rigorous and done with the specific system by using clear search and selection method it gives quick and easy way to get good usable information about the given topic (Aveyard 2010, 9-10; Cronin et al. 2008, 38).

5.2 Scientific article selection process

The studies for the literature review were searched from study and article databases Cinahl and PubMed. The search was done using all possible combinations of the key words with Boolean search operators (AND, OR). In the first search the Key terms used were "diabetic" OR "diabetes" AND "wound" OR "ulcer" AND "leg" OR "foot" OR "feet" OR "thigh" OR "lower body" OR "lower extremity" OR "lower limb" AND "prevention”. In the second search the key terms used were "diabetic" OR "diabetes" AND "wound" OR "ulcer" AND "leg" OR "foot" OR "feet" OR "thigh" OR "lower body" OR "lower extremity" OR "lower limb" AND "treatment" OR "healing". Both searches were conducted in March 2016. The search results can be found in table 2.

Table 1 shows the inclusion and exclusion criteria used to find studies that logically tied with the research questions. Limited language skills of the authors limited the search to two languages, Finnish and English, while the lack of funding limited the search to free full text studies. After the initial key word searches, the results were

filtered as per the inclusion criteria. These results were then screened into relevance by the title. The relevant studies were then further screened by the abstract into relevance or non-relevance. The full text of the studies deemed relevant after abstract screened, were then read. Those study answering the research question were included in the literature review. The chosen articles and studies are described shortly in appendix 1. Filtered results means that when all the initial results from using just the key terms are limited with the search engine to *Free full text* and studies found from years 2010-2016 only. Also in PubMed the results being reduced to only humans was considered in filtering and in Cinahl with *References available* and *Abstract available.*

Table 1. Inclusion and exclusion criteria

Inclusion criteria	**Exclusion criteria**
In English or Finnish	Not in English or Finnish
Free full text access	Considering non-diabetic foot ulcers
Peer reviewed	Considering ulcers not in lower extremities
Scientific publication	Duplicate studies
Answers the research question	Not based on clinical examinations and testing
Based on clinical examinations with real patients	
Published after the year 2010	

Table 2. Data selection process

Database used	Initial results	Filtered results	Relevance by the title	Relevance by the abstract	Based on inclusion category
Cinahl$_1$	411	23	16	10	5
Cinahl$_2$	1409	110	20	8	3

PubMed[1]	907	72	26	3	4
PubMed[2]	4442	204	50	6	4
Total	7169	409	112	27	16

1. The first search.
2. The second search.

Analysis and synthesis of data

Content analysis is a conventional method of analysis and is used in this research since it enables the analysis of different kinds of data, concurrently describing it (Kankkunen & Vehviläinen-Julkunen 2009, 133). It synthesizes study reports by offering a systematic way of categorizing and counting themes (Dixon-Woods, Agarwal, Jones, Young, Sutton & Noyes 2008, 94). When content analysis is inductive, it originates from the data (Kankkunen & Vehviläinen-Julkunen 2009, 135) and it is the choice of method in this research. When the essential information of the chosen articles and the results gathered are summarized and interpret, that is called data analysis. A lot of data from different sources are provided instead just only from one single article. (Aveyard 2010, 124, 128.)

6 Results

The results of the search for methods of diabetic leg wound prevention and treatment are presented in the following table, with their application method and amount of usage and effectiveness presented shortly. Methods of effective treatment and prevention of diabetic leg wounds are described in six main categories, which are further considered in detail.

Table 3. Categorized results of diabetic leg wound prevention and treatment, based on the included articles and studies

Method of prevention/treatment	**Application**	**Usage & effectiveness**	**Source(s)**

Metabolic control	Hyperglycaemia is strongly associated with poorer healing rated of ulcers and incidences of wound infection		Simms & Ennen 2010, 88 Turns 2012, 430 Begun et al. 2016
Infection prevention/control	Diabetics have a higher chance for infection in an ulcer, thus making it very important for active screening and quick control.	Infections are one of the main reasons diabetic wounds become chronic. Proper prevention of infection can prevent a wound from becoming chronic.	Simms & Ennen 2010, 88 Turns 2012, 427-428
Wound debridement	Debridement removes infective material from the wound, such as necrotic tissue furthering the wound healing process.	Biological debridement is seeing a resurgence. Surgical debridement is applied by surgeons. Mechanical debridement has long been seen as the golden standard of diabetic leg ulcers.	Simms & Ennen 2010, 89 Turns 2012, 430 Pettican & Baptista 2012, 27-33 Haycocks & Chadwick 2012, 51-58
Proper dressing selection	Each wound is different, and as such, the choice of a proper dressing for the situation helps optimize wound healing.	For practically every ulcer, some type of dressing is used. The choice of dressing can vary greatly from area to area, depending on the knowledge and materials available.	Simms & Ennen 2010, 89-90 Turns 2012, 432 Casey 2012, 24 Benbow 2012, 18
Assessment and education of diabetic foot	Regular assessment of a diabetic foot allows for early detection of developing ulcers or risk of ulcers	Proper screening and education of foot care can help prevent ulcers altogether if good compliance is found.	Turns 2012, 424-425 Crawford et al. 2007, 65-86 Boulton 2004, 1343–53 Cavanagh et al. 2000 Monteiro-Soares et al. 2012, 6-10

		Fernando et al. 2013 Lavery et al. 1998, 157-62
Pressure offload and footwear	Offloading pressure from the ulcer or a risky area of the foot with the help of different means, such as footwear, can aid in wound healing or prevention	Turns 2012, 430-431 Begun et al. 2016 Wounds international 2013 Apelqvist et al. 1990, 21-25 Macfarlane & Jeffcoate 1997, 867-70 Tyrrell & Carter 2009

Metabolic control

Results showed that stable or decreased HgbA1c level was clearly attributed to ulcer healing, whereas increased HgbA1c levels were associated with worse outcomes in wound healing. Common nursing interventions measuring the vital sings (e.g. blood pressure and blood glucose) is extremely important in preventing diabetic foot ulcers and also in assessing the correct method for treating one. (Marston, Hanft, Norwood, & Pollak, 2003.)

Infection prevention and control

The infection should be clinically observed by assessing the signs of infection, such as smell, purulent excretions, color, swelling, fever etc. Available evidence does not support using antibiotic treatments on a clinically uninfected wound as a means of infection prevention, but should be used if infection can clinically be observed. (Turns 2012, 430; Simms & Ennen 2010, 89.) Topical antimicrobial treatments or dressings can be used, such as dressings with silver or specific wound care honey, to help lessen the microbial load of a wound (Casey 2012, 22). Other hydrophobic dressings, such as Sorbact, don't directly kill bacteria, but their hydrophobic coating captures bacteria, and when the dressing is changed it also removes the captured bacteria (Dunder 2012).

Wound debridement

Debridement removes devitalized tissue from the wound, allowing a more normalized healing cycle. Routine debridement is considered standard care in chronic diabetic leg ulcers. (Simms & Ennen 2010, 89.) Debridement has been shown to significantly improve the healing times of diabetic leg wounds compared to non-debrided wounds (Haycocks & Chadwick 2012, 52). Debridement allows the full extent of the wound to be observed, removes a medium for bacterial growth and prepares the wound bed for the normal healing process (Haycocks & Chadwick 2012, 54). Debridement is an essential part of chronic wound treatment, but is of little use alone if the other key factors such as pressure offload, infection control and metabolic control are not also properly addressed (Haycocks & Chadwick 2012, 58).

Simms & Ennen (2010) propose that there are four main types of debridement: mechanical, biological, chemical and surgical. Haycocks & Chadwick (2012) however propose seven different types: Sharp/surgical, mechanical, autolytic, chemical, enzymatic, hydrosurgical and biological.

Surgical debridement is performed by surgeons in an operating theater. Sharp debridement is performed with sharp tools, and can be performed by a trained medical professional at the bedside (Haycocks & Chadwick 2012, 52). Wet-to-dry is another form of mechanical debridement, performed with wet dressings that are then allowed to dry, but it is impossible to differentiate between viable and nonviable tissue with it, and as such is not recommended anymore (Simms & Ennen 2010, 89). In autolytic debridement, a dressing such as hydrocolloids or hydrogels that provide a moist wound environment are used. This promotes enzymatic debridement by the body's own enzymes, softening and separating necrotic tissue. This method can however be very slow, and requires good circulation in the wound area. (Haycocks & Hadwick 2012, 54.) Using chemical debridement, certain compounds are used to break down necrotic tissue. Application of the chemical can however be difficult, and can damage viable surrounding tissue, and can be quite painful. (Haycocks & Hadwick 2012, 54.) Biological debridement is performed by maggots that use the necrotic tissue as nutrition, removing it from the wound. Maggot therapy has been

shown to be effective for wounds with resistant infection strains such as MRSA. They should not be used for wounds where the underlying bone tissue is suffering from osteomyelitis however, as the maggots can ingest this tissue. (Pettican & Baptista 2012, 29.) Biological debridement has shown similar results to autolytic debridement, except at a quicker pace (Haycocks & Hadwick 2012, 56).

Proper dressing selection

The proper choice of dressings for a diabetic leg wound is very important. The dressing serves to protect the wound from further trauma, prevent outside contamination and help control wound exudates and the level of moisture (Simms & Ennen 2010, 89). For diabetic wounds, the control of moistness is especially important. To prevent promoting bacterial growth, diabetic wounds with necrotic tissue should be kept dry (Turns 2012, 432; Benbow 2012, 18). Simple, cheap, easy to remove dressings are recommended by practitioners to allow easy check-ups on the wound. Occlusive dressings are contraindicated, as it is difficult to observe the wound under them and they might promote the growth of nonaerobic bacteria. (Turns 2012, 432; Benbow 2012, 18.)

Assessment and guidance of diabetic foot

Assessment of diabetic foot is extremely important. According to Turns (2012) the signs of increased risk of developing foot diseases with diabetic people are previous disease of the foot, distal symmetrical (peripheral) neuropathy, peripheral arterial disease, deformity of the foot sufficient to expose parts to abnormally high forces, established renal failure, immobilization due to comorbidity, visual impairment, oedema and reduced capacity for self-care. When assessing diabetic foot inspection it should include the identification of sensory neuropathy, whether the foot feels a monofilament, vibration or sharp touch, abnormal build-up of callus, absent foot pulses, sings of tissue ischemia or symptoms of intermittent claudication, deformities or problems with foot and previous assessments or operations done to the leg. (Turns 2012, 424-426.)

A common method for measuring the diabetic foot ulcer risk is the University of Texas classification scheme where the risk of diabetic foot ulcers is either low, medium, high or very high. Low risk means when person with diabetes has normal sensation, no foot deformations nor history of ulceration or amputation. At this state it is important to educate the person for self-care and prevention of the ulcer. When person with diabetes has lost the protective sensation, they fall in to medium risk category and are at increased risk of ulceration. At high risk, the person has foot deformities such as bunion, hammer toe or claw toe that increases even more the risk of ulceration. At this stage, the foot deformities cause abnormal gait that overloads at the metatarsal level and the hyperkeratosis can cause ulceration. When the person has diabetes, neuropathy, foot deformity and has history of ulceration or amputation, they are at very high risk of ulceration. In all of these cases it is important to consider what kind of footwear the diabetic person should have to protect their feet from ulcers. (Lavery, Armstrong, Vela, Quebedeaux & Fleischli 1998, 157-62.)

Pressure offload and footwear

According to studies reviewed, biomechanical abnormalities secondary to diabetic peripheral neuropathy are contributing cause to the formation of diabetic foot ulcers (Boulton 2004, 1343–53; Cavanagh, Ulbrecht & Caputo 2000; Monteiro-Soares, Boyko, Ribeiro, Ribeiro & Dinis-Ribeiro 2012, 6-10; Fernando, Crowther, Lazzarini, Sangla, Cunningham, Buttner & Golledge 2013). This is why specifically interventional footwear is important for person with leg ulcer (Wounds International 2013). Managing with diabetic foot, the footwear play an important role in the pathogenesis of foot complications (Apelqvist, Larsson & Agardh 1990, 21-25; Macfarlane & Jeffcoate 1997, 867-70). Good footwear for a diabetic should reduce abnormal pressure, limit the formation of callus and ulcers and protect from external trauma. Also it should be noted the level of activity of the person. (Tyrrell & Carter 2009). Appendix 3 shows suggested footwear for people with diabetes based on University of Texas scheme. (Lavery et al. 1998, 157-62).

7 Discussion

7.1 Main results and their implications for diabetic chronic wounds

The aim of this study was to find useful and applicable information regarding the diabetic foot ulcers. This study should help nurses to conduct appropriate methods in preventing and treating them, as well are they proven to be effective. Many methods can be found for the treatment and prevention of these wounds, but it should be noted that every person has a different medical background, and that every wound is ever so slightly different. Chronic diabetic ulcers require much thought and multidisciplinary intervention on a case-to-case basis. The results also emphasize, that the different methods are ultimately much more effective when used together in combination when needed. For example, surgical debridement of a wound matters very little, unless the cause of the wound is pinpointed and treated, for example with good metabolic control and pressure offload, and the wound is then treated with proper dressing choice.

Professional literature offers mostly the same means of prevention and treatment as the results of the conducted literature search. Juutilainen & Hietanen (2012) describe the importance of regular assessment of a diabetic foot, the proper choice of footwear and pressure offload if needed. Daily foot care, by application of cream, proper nail care and small foot exercises are also described (Juutilainen & Hietanen 2012, 345). These methods were also described by Hietanen et al. (2002) and by Flanagan (1997). Flanagan (1997) already in her book describes the importance of proper dressing selection, and debridement. These methods are also approved by Hietanen et al. (2002), and by Juutilainen & Hietanen (2012). Some additional information is described by Juutilainen & Hietanen (2012) that is not explored so in depth by the found articles and studies. They describe more in depth the difference between neuropathic and ischemic diabetic leg ulcers. While debridement is often considered a golden tool for wound care, with ischemic leg ulcers, debridement should NOT be

conducted, unless wet exudate is present under the dry devitalized tissue. Debridement can be conducted for such wounds after circulation has been restored to the area, often requiring surgical methods. (Juutilainen & Hietanen 2012, 347.)

Metabolic control is described as one of the cornerstones of foot ulcer prevention for diabetics by Flanagan (1997), Hietanen et al. (2002) and by Juutilainen & Hietanen (2012). Diabetes itself can narrow blood vessel and thus decrease the blood flow and the blood vessels may become calcified. It can cause ischemia and pain due to lower supply of oxygen in blood vessels. The nerves can also become damaged by elevated blood glucose levels and this leads to peripheral sensory neuropathy. Also the autonomy and motor neuropathy can make the diabetic foot more fragile. Autonomy neuropathy causes nerve damage to the sympathetic and parasympathetic nervous system causing cardiovascular changes (e.g. postural hypotension and tachycardia). (Drury & Gatling 2005.) Whereas motor neuropathy is dealing with nerves that supply the muscles, thus causing weakness and wasting of the muscles. This can cause also diabetic person to be unsteady and fall more often. (Newton & McInotsh 2008.) Long-term vascular and neurological complications of diabetes causes pain, increases risk of infection and ulceration of the sclerotic tissue (Hafner, Wimmershoff, Landthaler & Vogt 2004, 365-366). Marston et al. (2003) studied the treatment and control of hyperglycemia. They studied the effects of HgbA1c levels on wound healing as a variable on bioengineered human dermal substitute (Dermagraft).

Diabetics are at a high risk of developing infections of the foot, and at a tenfold risk compared to non-diabetics of hospitalization due to these infections (Turns 2012, 424). Infections of a diabetic foot are a result of complex interplay between neuropathy, impaired immune function and peripheral artery disease, PAD (Turns 2012, 424). Diabetic foot wounds are also at an increased risk of bone infection, osteomyelitis, which increases the likelihood of treatment failure and can lead to amputation (Turns 2012, 424). Flanagan (1997), Hietanen et al. (2002) and Juutilainen & Hietanen (2012) all also describe the importance of proper infection prevention and control for

diabetic leg ulcers, and describe infection as one of the major reasons why diabetic leg ulcers become chronic.

As a conclusion of this literary review it can be said that this study gives comprehensive information regarding diabetic leg ulcers, their prevention and treatment. Also it gives nurses quick and reliable methods for that. One of the main focus of this study was to keep in mind the life of a nurse or nursing student and when one is reading this, they could find easily information regarding the topic. Different treatment and prevention methods can help everyday life in the work, suggesting different ideas such as should the client with diabetic leg ulcer get better shoes to help in treatment of it and prevention of a new ulcer. Also the implications of this study can be used for practice and educational purposes for nurses working in wards or the kind of care that has clients with possible or current diabetic leg ulcers. The study can be further used in school to teach how to treat and prevent diabetic leg ulcers but also to show that how nursing techniques are case-by-case and multiple different solutions can be found for same type of problem. It is common for one type of illness, disorder, disability, syndrome, disturbance etc. to have many ways to treat it and applications should be revised case-by-case by looking the client's history, current situation, allergies and so on to give best treatment available.

The nursing technology and treatment methods change and are updated all the time, so it should be noted that new, more advanced and researched ones should be taken into consideration too, not only these found in this study. Further research from different methods can surely be found since the main idea of this study was to give insight into common and proven to be functional, practical methods for treating diabetic leg ulcers.

7.2 Ethical considerations, validity & reliability

The Logan University Literature Review: Ethical Issues (2016) guideline highlights the importance of honesty with professional colleagues. This means reporting the findings of the literature review with complete honesty, not misrepresenting the findings

of previous researches and studies, not misinforming or intentionally misleading with the results and giving appropriate credit. Plagiarism is also a consideration, and should be avoided with proper acknowledging of sources. (Logan University 2016.)

Other ethical considerations in a literature review come from biases. Understanding research bias allows readers to critically and independently review the research literature (Pannucci & Wilkins 2010, 1). Bias is nearly always present in a study to differing degrees, and can happen at any phase of study (Pannucci & Wilkins 2010, 1-2). Biases identified by the authors in this thesis include language, selection and availability bias. Language bias in this case means that only studies and articles in either Finnish or English were chosen, and the possibility that relevant studies in other languages were excluded should be considered. Availability bias refers to the fact that due to resource constraints, only free full articles and studies were used. The possibility that studies and articles with relevant information were excluded because of paywalls. Selection bias means, that if this literature review was conducted by persons from different ethnic backgrounds or from different socioeconomic backgrounds, they might have chosen different articles and studies than those currently chosen. This should also be considered, when conducting such literature reviews in the future. The studies and articles chosen were conducted in different regions of the world, and can thus be applicable to different cultural views. See Appendix 2 for the countries in which the studies and articles were conducted or released.

When the research is a collection of already known research knowledge done by one or multiple professionals, it gives a general view of a specific topic. Although it should be noted that the collection is done from a *specific perspective* from specific professional(s). This means that the narrative literature review is predisposed by the researcher's own background and personal experiences (Saks & Allsop 2007, 34). The person reading the research should trust that the professional(s) has used adept ways to find the information. This could arise as a problem when one is examining the research critically (Cook et. al. 1997, Klassen et al. 1998, Jones & Evans 2000). Also the sample representatives and its size affects validity. If the sample is only from

specific hospital, economical class, country etc. it cannot be applied elsewhere for example in another country (Gerrish & Lacey 2010, 25). In this study, there were studies from all different countries and settings to increase the validity (see appendix 2).

Reliability is the consistency of measurement in the study. Testing reliability works by repeating the measurements, for example doing the same questionnaire under similar conditions multiple times (Gerrish & Lacey 2010, 25).

Some of the studies found with literature review are systematic literature reviews. They are very good since they give high-quality researches (Sackett et al. 1996). Systematic literature review is secondary research conducted on already, precisely defined, cropped and chosen researches. It is focused on researches done at specific time era and it should be revised to keep up the relevance of the results. (Shojania et al. 2007.) Systematic literature review differs from other literature reviews by its specific meaning and especial accurate choosing, analyzing and synthesizing studies. Systematic literature review includes only the relevant and significant for the purpose of the researches. (Cook et al. 1997, NHS 2001, Cochrane database 2007.)

References

Apelqvist, J., Larsson, J. & Agardh, CD. 1990. *The influence of external precipitating factors and peripheral neuropathy on the development and outcome of diabetic foot ulcers.* J Diabet Complications 4(1): 21–25.

Aveyard, H. 2010. *Doing a Literature Review in Health and Social Care: A Practical Guide*. 2nd Edition. Open University Press. England: McGraw-Hill Companies.

Begun, A., Morbach, S., Rümenapf, G., Icks, A. 2016. *Study of Disease Progression and Relevant Risk Factors in Diabetic Foot Patients Using a Multistate Continuous-Time Markov Chain Model.*

Benbow, M. 2012. *Diabetic foot ulcers.* Journal of Community Nursing vol. 26. 16-19.

Boulton, AJM. 2004. *The diabetic foot: From art to science*. The 18th Camillo Golgi lecture. Diabetologia; 47(8):1343–53.

Burns, N. & Grove, S. 2005. *The practice of nursing research. Conduct, critique & utilization*. 5th Edition. Philadelphia: WB Saunders Company

Casey, G. 2012, *Modern advances in wound care.* Kai Tiaki Nursing New Zealand vol 18 no 5, 20-24.

Cavanagh, PR., Ulbrecht, JS. & Caputo, GM. 2000. *New developments in the biomechanics of the diabetic foot.* Diabetes/Metabolism Research Reviews; 16(Suppl 1):6–10.

Crawford, F., Inkster, M., Kleijnen, J., Fahey, T. 2007. *Predicting foot ulcers in patients with diabetes: a systematic review and meta-analysis*. 65-86.

Cook, DJ., Murlow, CD., Haynes, RB. 1997. *Systematic reviews: synthesis of best evidence for clinical decisions*. Annales of International Medicine 126, 376-80.

Cochrane Databse of Systematic Reviews CDSR. 2007. Accessed 12.3.2016 at 16:06. Retrieved from www3.interscience.wiley.com/cgibin/mrwhome/106568753/productdescriptions.html.

Cronin, P., Ryan, F. & Coughlan, M. 2008. *Undertaking a literature review a step-by step approach*. British Journal of Nursing 2008 January. 38. – 43.p. Mar Allen Publishing Ltd.

Dixon-Woods, M., Agarwal, S., Jones, D.R., Young, B., Sutton, A. J. & Noyes, J. 2008. *Synthesising qualitative and quantitative evidence within a systematic review. In Nursing research: Designs and methods.* Ed. by Watson, R., McKenna, H., Cowman, S. & Keady, J. Edinburg: Churchill Livingstone.

Drury, P. & Gatling, W. 2005. *Diabetes: Your Questions Answered.* Churchill Livingstone, Edinburgh

Dunder, U. 2016. *Säärihaavapotilaan hoitotyö [Nursing care of a leg ulcer patient]*. Sorbact wound care training session 25 February 2016. Retrieved from http://docplayer.fi/12877864-Saarihaavapotilaan-hoitotyo-sh-yamk-auktorisoitu-haava-hoitaja-ulla-dunder.html

Fernando, M., Crowther, R., Lazzarini, P., Sangla, K., Cunningham, M., Buttner, P. & Golledge, J. 2013. *Biomechanical characteristics of peripheral diabetic neuropathy: A systematic review and meta-analysis of findings from the gait cycle, muscle activity and dynamic barefoot plantar pressure.* Clinical Biomechanics.

Flanagan, M. 1997. *Wound Management.* 1st ed. London: Churchill Livingstone.

Gerrish, K. & Lacey, A. 2010. *The Research Process in Nursing*. 6th Edition. 24. – 432.

p. Blackwell Publishing Ltd.

Greener, J. & Grimshaw, J. 1996. *Using meta-analysis to summarise evidence within systematic reviews.* Nurse Researcher 4, 27-38.

Greg, G., (2012). *Applied thematic analysis*. Thousand Oaks, California: Sage. p. 11.

Haycocks, S. & Chadwick, P. 2012. *Debridement of diabetic leg wounds.* Nursing Standard 26, 24, 51-58.

Hafner, C., Wimmershoff, M., Landthaler, M. & Vogt, T. 2004. *Lipodermatosclerosis: successful treatment with Danazol*. Acta Dermato-Venereologica, 85, 365-366.

Haycocks, S. & Chadwick, P. 2012. *Debridement of diabetic leg wounds.* Nursing Standard 26, 24, 51-58.

Hietanen, H., Iivanainen, A., Seppänen, S., & Juutilainen, V. 2002. *Haava [Wound].* 1st ed. Porvoo: WSOY.

Honkanen, J., Laitinen, L., Talola, S., & Tiippana, A. 2008. *Diabeetikoiden riskijalkojen tutkiminen ja hoito terveyskeskuksissa [Assessment and treatment of diabetic risk feet in healthcare centers].* Diabetes ja Lääkäri, vol. 37, 20-22.

Iivanainen, A., Jauhiainen M., & Syväoja. P. 2012. *Sairauksien hoitaminen [Treatment of diseases].* 3rd-5th ed. Helsinki: SanomaPro.

Johansson, K., Axelin, A., Stolt, M. and Ääri R-L. 2007. *Systemaattinen kirjallisuuskatsaus ja sen tekeminen*. University of Turku, Department of Nursing Science Research reports, 51.

Jones, T. & Evans, D. 2000. *Conducting a systematic review*. Australian Critical Care 13, 66-71.

Juutilainen, V., & Hietanen, H. 2012. *Haavanhoidon periaatteet [Principles of wound care].* 1st ed. Helsinki: SanomaPro.

Kangas, T. 2002. *Diabeetikkojen terveyspalvelut ja niiden kustannukset. Helsinkiläisten diabeetikkojen verrokkikontrolloitu poikkileikkaustutkimus [The consumption and direct costs of health care services among persons with diabetes in Helsinki. A case controlled cross-sectional study of the fiscal year 1997].* Jyväskylä: Gummerus.

Korhonen, K., & Lepäntalo, M. 2012. *Ongelmahaavojen hoitoketjun kehittäminen tehostaa hoitoa ja tuo säästöjä [Developing the care path of problematic wounds raises the effectiveness of care and brings savings].* Lääkärilehti 43/2012.

Kankkunen, P. & Vehviläinen-Julkunen, K. 2009. *Tutkimus hoitotieteessä.* Helsinki: WSOYpro Oy.

Kankkunen, P. & Vehviläinen-Julkunen, K. 2013. *Tutkimus hoitotieteessä*. 3rd Edition. 164. p. SanomaPro Oy.

Khan, KS., Kunz, R., Kleijnen, J. & Antes, G. 2003. *Systematic Reviews to Support Evidence-based Medicine, How to review and apply findings of healthcare research*. London: The Royal Society of Medicine Press Ltd.

Klassen, TP., Jadad, AR., Moher, D. 1998. *Guides for reading and interpreting systematic reviews: Getting started*. Archives of Pediatrics and Adolescent Medicine 152, 700-4.

Lavery, LA., Armstrong, DG., Vela, SA., Quebedeaux, TL. & Fleischli, JG. 1998. *Practical Criteria for Screening Patients at High Risk for Diabetic Foot Ulceration*. Arch Intern Med 158(2): 157–62.

Liamputtong, P. 2013. *Research Methods in Health - Foundations for evidence-based practice*. 2nd Edition. 16. – 376. p. Oxford University Press Australia.

Logan University. 2016. *Literature Review: Ethical Issues.* Learning Resources Center. Accessed 9 May 2016 http://libguides.logan.edu/c.php?g=181964&p=1198011

Macfarlane, RM. & Jeffcoate, WJ. 1997. *Factors contributing to the presentation of diabetic foot ulcers*. Diabet Med 14(10): 867–70.

Magarey, JM. 2001. *Elements of systematic review*. International Journal of Nursing practice 7, 376-82.

Marston, WA., Hanft, J., Norwood, P. & Pollak R. (2003). *The efficacy and safety of Dermagraft in improving the healing of chronic diabetic foot ulcers.* Diabetes Care 26, 1701–1706.

Meade, MO. & Richardson, WS., 1997. *Selecting and appraising studies for a systematic review.* Annals of Internal Medicine 127 (7), 531-537.

Moakes, H. 2012. *An overview of foot ulceration in older people with diabetes.* Nursing Older People; 24(7): 14-19.

Monteiro-Soares, M., Boyko, E., Ribeiro J., Ribeiro, I. & Dinis-Ribeiro, M. 2012. *Predictive factors for diabetic foot ulceration: a systematic review.* Diabetes/metabolism research and reviews.

Nemcová, J. & Hlinková, E. 2014. *The efficacy of diabetic foot care education.* Journal of Clinical Nursing; 23, 877–882.

Newton, V. & McIntosh C. 2008. *Neuropathy: gait changes in the diabetic foot.* Wound Essentials, 3, 152-155.

NHS Centre for reviews and dissemination. 2001. *Undertaking Systematic Reviews of Research on Effectiveness*. CRD Report 4, 2nd ed. The University of New York, NHS Center for Reviews and Disseminations, York. Accessed 12.3.2016 at 16:08. Retrieved from http://www.york.ac.uk/inst/crd/report4.html.

Niemi, T. 2015. *Kroonisten haavojen hoitoa tehostetaan Tyksissä [Chronic wound care is being improved in Tyks].* Aamuset.fi 5.10.2015.

Oxman AD., 1994. *Systematic reviews: Checklist for review articles*. British Medical Journal 309 (6955), 648-651.

Pannucci, C. & Wilkins, E. 2010. *Identifying and Avoiding Bias in Research.* Plastic and Reconstructive Surgery 126(2), 619–625.

Pettican, A. & Baptista, C. 2012. *Maggot Debridement Therapy and its role in chronic wound management.* Singapore Nursing Journal vol. 39, 22-33.

Petticrew, M. 2003. *Why certain systematic reviews reach uncertain conclusions*. British Medical Journal (BMJ) 326, 756-8.

Sackett, DL., Rosenberg, WMC., Gray, JAM., Haynes, RB. & Rishardson, WS. 1996. *Evidence based medicine: what is it and what it isn't.* British Medical Journal (BMJ) 312, 71-2.

Saks, M. & Allsop, J. 2007. *Researching Health Qualitative, Quantitative and Mixed Methods*. 30. – 124. p. Sage Publications.

Shojania, KG., Sampson, M., Ansari, MT., Ji, J., Doucette, S., & Moher, D. 2007. *How quickly do systematic reviews go out of date? A survival analysis*. Annales of International Medicine 147, 224-33.

Simms, K. & Ennen, K. 2010. *Lower extremity ulcer management: best practice algorithm.* Journal of Clinical Nursing 20, 86-93.

Turns, M. 2012. *The diabetic foot: an overview for community nurses.* British Journal of Community Nursing 17, 422-433.

Tyrrell, W. & Carter, G. 2009. *Therapeutic Footwear, A Comprehensive Guide*. Churchill Livingstone, London.

Välimäki, M., Sane, T., & Dunkel, L. 2009. *Endokrinologia [Endocrinology].* 2nd ed. Helsinki: Duodecim.

Wounds International. 2013. Diabetic foot 4(3).

Appendices

Appendix 1: Table of chosen articles and studies

Authors and time	Aim	Sample size, participants	Data collection	Results
Casey, G. 2012.	Describing different types of chronic wounds and dressing types used in their treatment.	Data not available	Article, peer reviewed	Chronic wounds require skilled management, and knowledgeable nurses, to allow improved practice in wound care.
Simms, K. & Ennen, K: 2010.	To define the best nursing practice for lower limb ulcer care.	29 articles chosen for the literature review	Literature review	Control of hyperglycemia, debridement of ulcers, control of infections, and proper dressing choice were

				all identified as important factors for lower limb ulcer healing.
Pettican, A. & Baptista, C. 2012.	Studying the effectiveness of maggot therapy in the debridement of chronic wounds.	14 participants	Clinical research and trial	The results show maggot therapy as an effective way of debridement, with 64,28% of participants returning successful outcomes.
Turns, M. 2012.	The article offers a podiatrist's view on the management of diabetic foot problems.	Data not available	Article, peer reviewed	A multidisciplinary team is required to effectively prevent non-healing ulcers.
Haycocks, S. & Chadwick, P. 2012.	The article outlines the core principles of best practice diabetic	Data not available	Article, peer reviewed	Debridement is a critical part of preparing a

	foot ulcer patients, focusing on debridement.			wound bed for healing, though it is of little use if used as the sole means of treatment.
Benbow, M. 2012.	The article explores risk factors and prevention strategies of diabetic foot ulcers.	Data not available	Article, peer reviewed	Education is very important for the prevention of diabetic foot ulcers. Compliance however, can be difficult to achieve for preventive measures.
Marston, WA., Hanft, J., Norwood, P. & Pollak R. (2003).	Using artificial skin, Dermagraft, and studying the HgbA1c levels on wound healing compared to human tissue.	Artificial skin, Dermagraft and 314 patients with diabetic foot ulcer.	Clinical research and trial	Hyperglycaemia is strongly associated with poorer healing rated of ulcers and incidences of wound infection.

Fernando, M., Crowther, R., Lazzarini, P., Sangla, K., Cunningham, M., Buttner, P. & Golledge, J. 2013.	A systematic review and meta-analysis investigated the effect of diabetic peripheral neuropathy on gait, dynamic electromyography and dynamic plantar pressures.	382 neuropathy participants, 216 diabetes controls without neuropathy and 207 healthy controls, 805 in total.	Article, peer reviewed	Meta-analysis results suggested a longer stance time and moderately higher plantar pressures in diabetic peripheral neuropathy patients at the rearfoot, midfoot and forefoot compared to controls. Systematic review of studies suggested potential differences in the biomechanical characteristics (kinematics, kinetics, EMG) of diabetic neuropathy patients.

				However these findings were inconsistent and limited by small sample sizes.
Moakes, H. 2012.	A brief overview of the main complications associated with diabetes and discusses the different types of diabetic neuropathy. Risk factors in the development of diabetic foot ulcers are identified and the importance of timely assessment is recognized.	Data not available.	Literature review	It is important to recognize and properly act in a case of diabetic foot ulcer. Nurses should be able to also know where to contact and find information in case they need to know more about the case.

Begun, A., Morbach, S., Rümenapf, G., Icks, A. 2016.	Developing a nine-state continuous-time Markov chain model for quantifying	260 long-term patients	Clinical research and trial	This study helps us to better understand complex interplay of active and inactive episodes of diabetic foot disease and will now be used to comprehensively analyze larger prospective datasets from patients with diabetes and lower extremity complications.
Nemcová, J. & Hlinková, E. 2014.	To survey the efficacy of education about factors that influence the learning process	100 participants with type 2 diabetes, 52 diabetic participants with diabetic foot syndrome and 48 diabetic	Clinical research and trial	The clinical parameters (weight, Body Mass Index, blood pressure) demonstrated a statistically

	and behaviour of diabetics following a nursing interventional project in diabetic foot care education.	patients with ischaemic disease of lower extremities.	significant positive change six months after education.

Appendix 2: Inclusion category studies and the different countries they were conducted in.

Study	Country
Simms, K. & Ennen, K: 2010.	USA
Pettican, A. & Baptista, C. 2012.	Three **Singapore** hospitals participated in MDT
Marston, WA., Hanft, J., Norwood, P. & Pollak R. 2003.	35 centers throughout the **U.S.** and enrolled 314 patient
Begun, A., Morbach, S., Rümenapf, G., Icks, A. 2016.	Germany
Nemcová, J. & Hlinková, E. 2014.	Slovakia

Appendix 3: Suggestions for appropriate footwear for people with diabetes in relation to the individual's risk of ulceration (based on the Texas Scheme). Wounds International. 2013. Diabetic foot 4(3).

Table 1. Suggestions for appropriate footwear for people with diabetes in relation to the individual's risk of ulceration (based on the University of Texas scheme[89]).

	LOW	MEDIUM	HIGH	VERY HIGH
LEVEL OF RISK	• Normal foot sensation. • No foot deformity. • No history of ulceration or amputation.	• Neuropathy. • No foot deformity. • No history of ulceration or amputation.	• Neuropathy. • Foot deformity. • No history of ulceration or amputation.	• Neuropathy. • Foot deformity. • History of ulceration or amputation.
ADVICE ON FOOTWEAR	Clinicians should encourage people with diabetic neuropathy to compensate for their loss of pedal sensation by assessing socks and shoes by sight and touch for foreign objects or irregularities. Walking barefoot should be discouraged. Mended socks should avoided.			
	Retail footwear. No change in footwear is necessary at this level of risk. Clinicians may encourage selection of retail footwear as described below.	**Well-fitted retail footwear, insoles.** People at this level of risk should be encouraged to not wear the same pair of shoes for prolonged periods.	**Therapeutic footwear, commercial or custom-made insoles.**	**Therapeutic footwear, multilayered custom-made insoles.**
	Retail footwear should: • Be accurately measured to fit the foot and accommodate insoles in all dimensions. • Have soft, preferably heat-sensitive, uppers. • Incorporate soles or insoles that efficiently absorb vertical forces.		Therapeutic footwear should include: • Recessed heels. • Rigid, or rigid rocker-bottom soles. • A wide angle between the sole and the ground at the most anterior part of the shoe.	
EXAMPLES	Laced Oxford shoe in soft leather. 	Shoe with rigid sole and custom-made insoles. 	Shoe with rigid rocker-bottom sole and a custom-made multilayered insole.