

Research Article

Modeling and Simulation of Bladder Problems in Patients with Fibromyalgia

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Abstract

The Fibromyalgia is a disease that associated with chronic pain disorders and is also known as Fibromyalgia Syndrome (FMS). The women are more likely to suffer from fibromyalgia than men. Chronic muscle pain, chronic fatigue syndrome, frequent urination, migraine, depression are most important symptoms of fibromyalgia. The treatments of fibromyalgia are medicinal therapies, non-pharmacological treatments and alternative treatments. Most women suffering from fibromyalgia have a chronic urinary infection that can lead to incontinence. The Fibromyalgia disrupts daily activity of patients and can have a serious impact on these patient's lives and work. One of the symptoms of this disease is frequent urination which results in urinary incontinence.

Keywords: Fibromyalgia; Diagnosis of fibromyalgia

Introduction

The fibromyalgia was recognized by the American Medical Association in 1987 as a disease. It is associated with chronic pain disorders. Fibromyalgia is also known as fibromyalgia syndrome (FMS). In most cases, fibromyalgia occurs between the ages of 25 and 55 and is less common in younger adults. Women are more likely to suffer from fibromyalgia than men. Women aged 20 to 50 years are the most affected. Individuals suffering from fibromyalgia have a low pain threshold. Reducing the pain threshold for people suffering from fibromyalgia is due to increased sensitivity of the brain to pain symptoms. Although fibromyalgia is associated with arthritis, actually it is not arthritis, because it does not inflammation and damage the tissues and joints, but it causes a lot of pain and fatigue in patients. Fibromyalgia disrupts daily activity of patients. This disease does not reduce the longevity of patients. Fibromyalgia does not cause any other illness, but it affects the functioning of the patients in the house and in the workplace because of the pain and the lack of sleep [1-4].

The most important symptoms of fibromyalgia include the following (Figure 1):

a) Chronic muscle pain: in general, pain caused by fibromyalgia beget in joints, tendons and other soft tissues. The points of incidence of pain in fibromyalgia are: behind the head, between shoulder blade, chest, shoulder, front of the neck, outer part of elbow, sides of pelvis, inner part of the knee, arms, abdomen areas and back of hand. Pain usually worsens with activity, cold and humid weather, anger and stress.

b) Chronic fatigue syndrome/Encephalomyelitis (inflammation of the brain and spinal cord): many of these patients have sleep disorders such as sleep apnea and restless legs syndrome [5].

c) Frequent urination and dysuria: frequent urination is a common problem in fibromyalgia syndrome is usually the need of patients to urinate. As mentioned, some people suffering from fibromyalgia syndrome find they should usually wake up during the night to go to the bathroom and get to the toilet regularly throughout

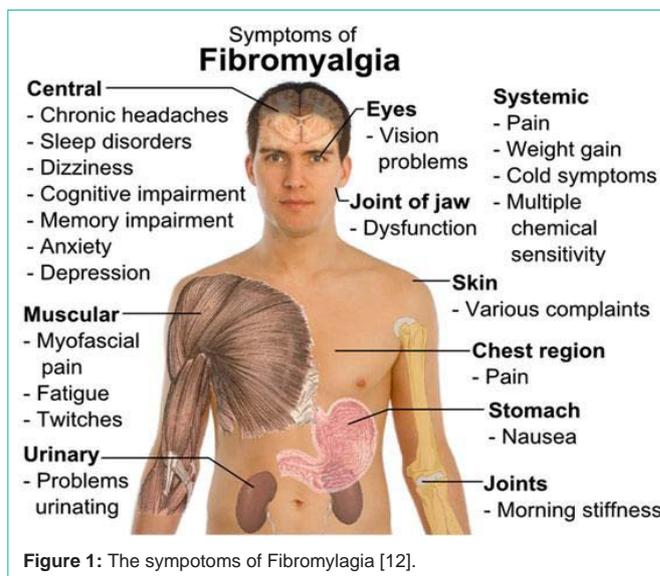


Figure 1: The symptoms of Fibromyalgia [12].

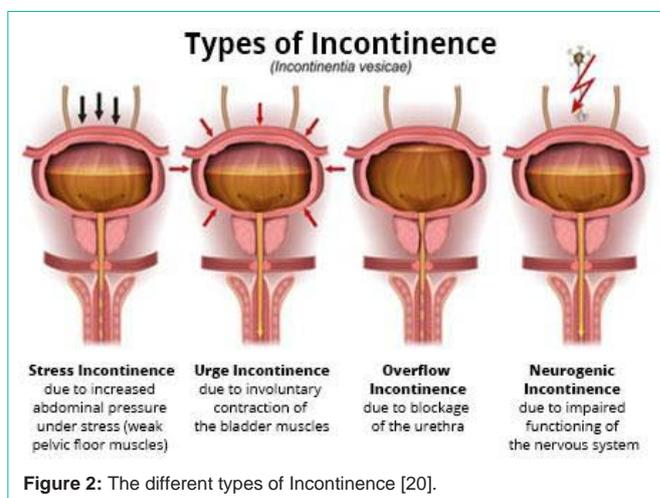


Figure 2: The different types of Incontinence [20].

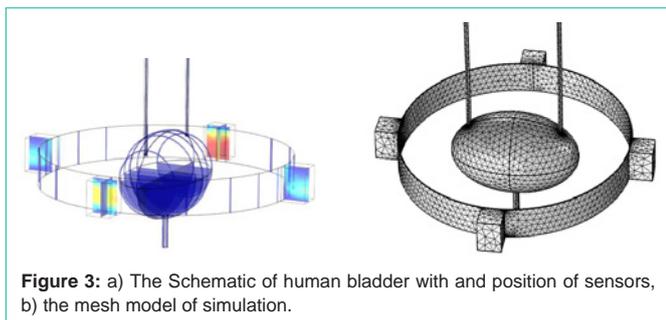


Figure 3: a) The Schematic of human bladder with and position of sensors, b) the mesh model of simulation.

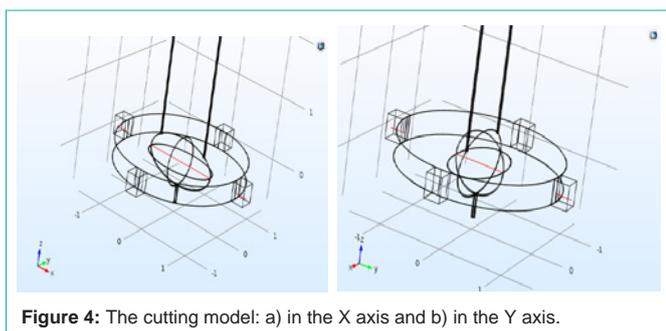


Figure 4: The cutting model: a) in the X axis and b) in the Y axis.

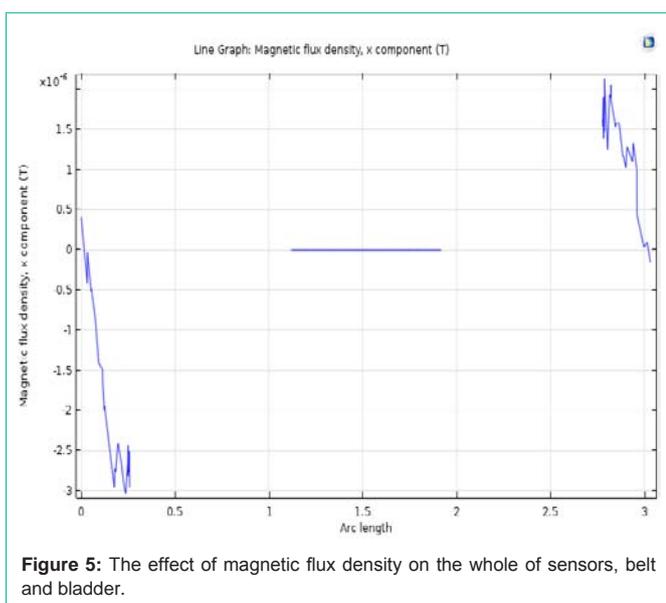


Figure 5: The effect of magnetic flux density on the whole of sensors, belt and bladder.

the day. This problem can have a significant effect on the patient's sleep patterns [6-9].

d) Irritable Bladder Syndrome: need to go to the bathroom more than usual.

e) Irritable bowel syndrome: generally, occurs in people suffering from fibromyalgia and associated with abdominal pain and occasionally diarrhea, constipation, bloat, and nausea.

f) Problems of concentration and memory: it weakens the ability to focus, attention, and self- definitude in mental work.

g) Tension headache or migraine.

h) Depression and anxiety [10].

i) Dysmenorrhea: it can be seen in some women suffering fibromyalgia [11,12].

Diagnosis of fibromyalgia

Although there are no laboratory tests to confirm the diagnosis of fibromyalgia, the physician with the blood test can see that whereof symptoms of fibromyalgia have originated. Blood tests should include: blood cell count-erythrocyte sedimentation rate (RBC)-thyroid function test.

The American association of rheumatology defines fibromyalgia syndrome as a syndrome with a released pain in 11 or more than 18 specific points. The main tests are CBC, ESR, standard biochemistry tests and thyroid function tests [13,14].

Fibromyalgia treatment

The treatment of fibromyalgia includes

a) Medicinal Therapies: U.S. Food and Drug Administration have been approved three types of medicine used to treat fibromyalgia which include: Lyrica (Pregabalin), Cymbalta (Duloxetine), Savella (Milnacipran); another types of drug used to treat fibromyalgia include: anti-inflammatory drugs, ataractic (acetaminophen, tylenol, other specimens), ibuprofen (advil, Motrin IB, other specimens) or Naproxen Sodium, anti-depressants (Elavil (amitriptyline), Cymbalta (duloxetine)and milnacipran), analgesics, anticonvulsants, sometimes gabapentin (Neurontin, Gralice)is useful in reducing the symptoms of fibromyalgia and CNS stimulants are used to treat fibromyalgia [15,16].

b) Non-pharmacological treatment of Fibromyalgia includes: good and varied eating, drink less caffeine, massage, physiotherapy, cardiovascular exercises, electromyogram, biofeedback, mineral water springs, balneotherapy and Cognitive-Behavioral Therapies (CBT) [17].

c) Alternative treatments include: chiropractic, deep tissue massage, neuromuscular massage, meditation, herbal medicines, supplements, such as amino acids HTP-5, St. John's wort, L-carnitine, SAM-e and probiotics [1,2].

Incontinence

Different types of this disorder include (Figure 2):

1) stress incontinence, 2) urge incontinence, 3) overflow incontinence, 4) neurogenic incontinence [18,19]

The cause of urinary incontinence with fibromyalgia may be due to fatigue or weakening of the bladder muscle. Most women suffering from fibromyalgia have a chronic urinary infection that can lead to incontinence [20,21].

Effective treatments for urinary problems and incontinence include: physiotherapy for muscle staddle pelvis, Kegel exercises, regular physical activity, electrical stimulator, surgery may also be delayed in the excretion of urine and better bladder protection to prevent incontinence, Antihypertensive drugs, diuretics, antidepressants, contraceptives, sleep medications, oral estrogens, bladder training, botox can be injected into the bladder muscle with the aim of calming the muscle and increasing its storage density, pessary device that is a plastic device that enters the vagina and can help prevent leakage of the urine by supporting the bladder neck and

Table 1: The related parameters of simulation.

Urinary parameters	Electrical conductivity	Relative permeability	Relative permittivity
	21.5[S/m]	0.999	80.1
Bladder parameters	Electrical conductivity	Relative permeability	Relative permittivity
	1000[S/m]	1	11.7
Belt parameters	Electrical conductivity	Relative permeability	Relative permittivity
	0	1.2	5.8
Sensor parameters	Electrical conductivity	Relative permeability	Relative permittivity
	8.9e6[S/m]	1.006	2.7604

catheterization [22-25].

Materials and Methods

Medicinal Therapies, pharmacological, non-pharmacological and alternative therapies for treating and preventing self-urinary disorders in patients with fibromyalgia include the use of protective shields, catheters, bladder training, catheterization, etc.

The self-urinary disorder causes patients with fibromyalgia to have poor sleep patterns and can have a serious impact on these patient’s lives and work.

We are planning to design a non-invasive approach to eliminating self-urinary disorder in patients with fibromyalgia and also for preventing self-urinary disorders which consists of a belt and four intelligent sensors surrounding it. The Sensors mounted on the belt measure the volume of urine in the bladder at all moments and send a command before the volume of urine into the bladder reaches the first threshold of pain to the warning system that it’s in the form of a wristband. The patient will be informed urine volume’s condition within the bladder by receiving a warning from the wristband and before the bladder gets out of control and the patient urinate, it inform the patient of this condition.

In this research, the proposed method is simulated by Comsol multiphysics finite element analysis software. The Comsol software is selected and utilized for this simulation as an analysis program due to the Comsol multiphysics software is a simulation complete collection that allows users to simulate in 3D space. This software can function very well in the face of challenges such as electric and magnetic fields, as well as the consideration of electrical and magnetic parameters and their inclusion. The Comsol gives the user an opportunity to solve any technical problems by choosing of the physical environment. In the Comsol function area, all three stages: preprocessing, processing and post-processing are performed. In this simulation, we chose the electrical section that includes modules for simulating electrical and magnetic systems. It is worth mentioning that in Comsol, the results can be drawn into arbitrary shapes and in different geometries. The model parameters are presented in Table 1.

Simulation and Results

The area that has been chosen for this study and simulation, is Electric Currents and Magnetic Fields. For this simulation, in addition to existence the bladder, we need the ureters for entering the urine into the bladder and the urethra for exit the urine from the bladder. The ureters are placed on top of the bladder and on both

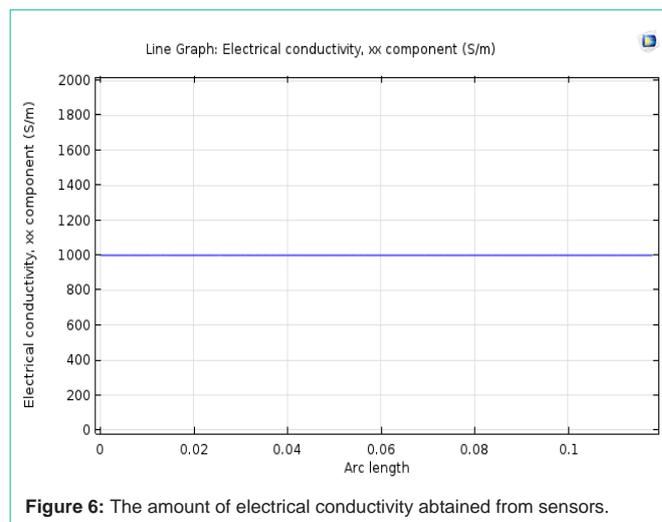


Figure 6: The amount of electrical conductivity obtained from sensors.

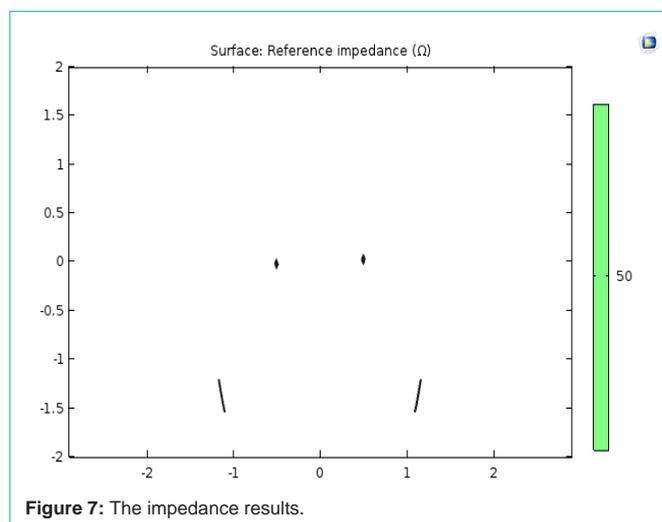


Figure 7: The impedance results.

sides of it, and the urethra is located below the bladder. The ureters and the urethra are like cylindrical tubes. Given that the bladder is close to the elliptical geometry and the ureters and the urethra are close to the cylindrical shape, we selected two geometric elliptic and cylindrical shapes for simulation. The volume of the bladder full of urine in a normal state is 450 ml, so we consider the oval volume at the maximum of 450 cubic centimeters. Given that the bladder has an elastic property, silicon is used to simulate the bladder. Urinary traits such as electrical conductivity, relative permeability and relative permittivity are considered in this simulation.

The sensors should send the alarm to the warning before the first pain threshold, the amount of urine with the characteristics considered is equal to the amount of urine that causes the first threshold of pain in women. This amount is 44% of the total bladder volume in women. To simulate the belt, we provided reference the European standard for women waist size that it’s 80 cm, and we have chosen the PVC for belt material. Since our goal is to measure the increasing of the volume of the bladder, we put four platinum sensors on four sides of the belt. In Figure 3 the image and mesh model of belt and bladder have been demonstrated.

To analyze the proposed model need to study it in two direction

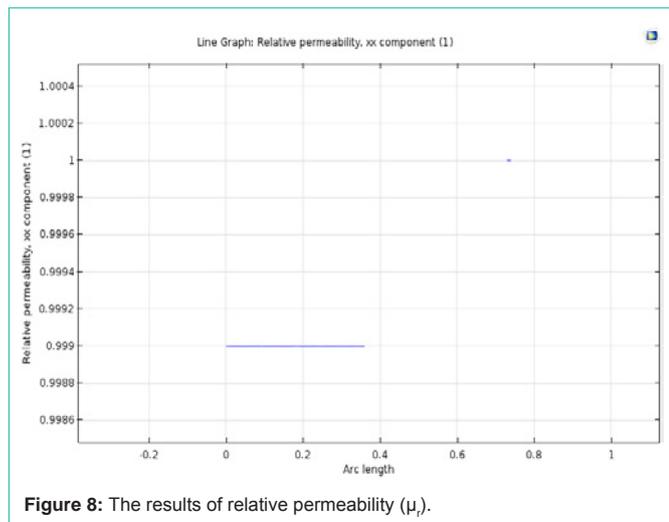


Figure 8: The results of relative permeability (μ_r).

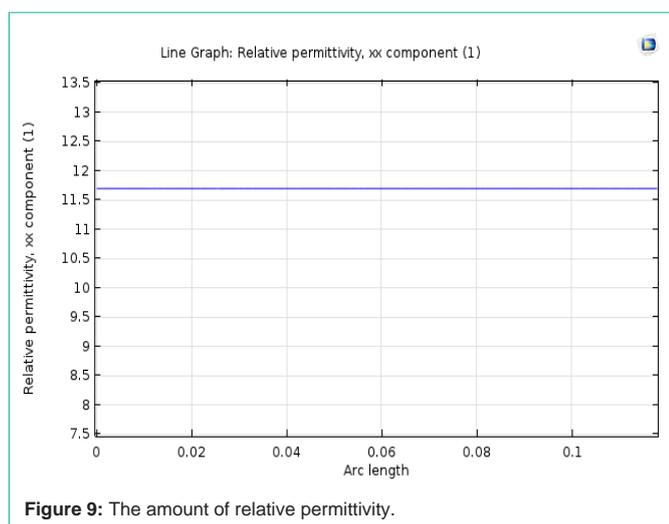


Figure 9: The amount of relative permittivity.

X and Y which presented in Figure 4a and b.

The study of magnetic flux density in Tesla unit on the whole simulation environment is shown in Figure 5. The side sections of shape related to the belt and the middle part is associated with the bladder. The middle part that is associated with the bladder is zero. Obviously, the magnetic flux should not affect to the bladder, but the magnetic flux affects for these sections are related to the belt of sensors.

The indicates electrical conductivity which is equal to the magnitude of the current density (J_0) and its value is equal to 1000 (A/m^2) to create the magnetic fields. Considering the amount of J_0 , the Figure 6 shows the electrical conductivity as 1000, which means that none of the energies not being wasted somewhere.

The reference impedance results are validated in Figure 7. The middle section is zero and impedance effects on the side sections. The reason for the impedance being negative in the lateral parts is that it probably measures the reverse.

The Figure 8 shows the relative permeability (μ_r) results which obtained from simulation and the result is referring the parameters

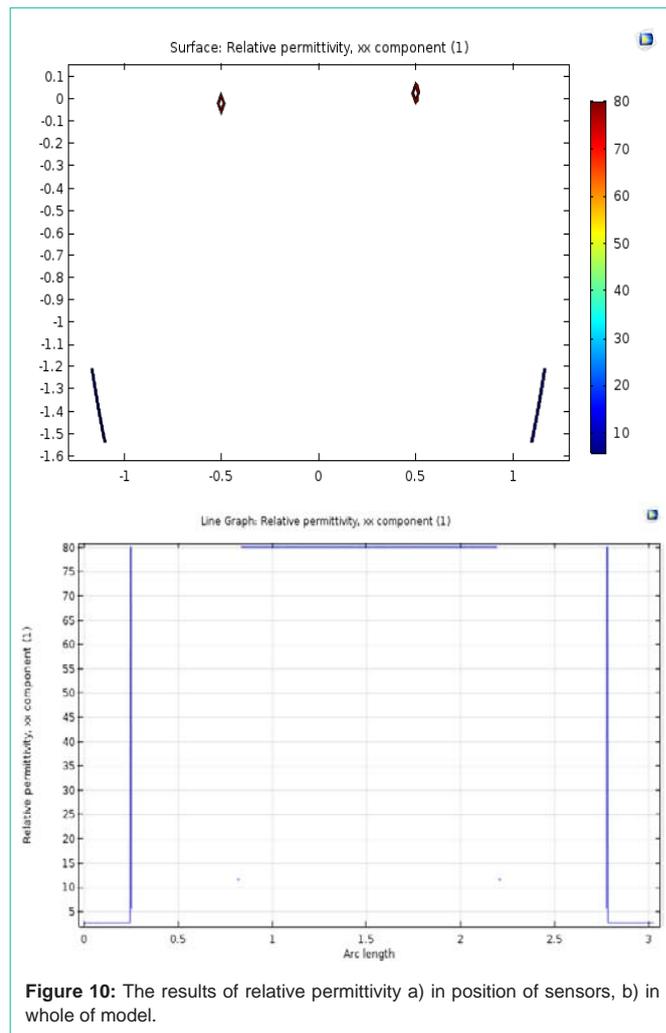


Figure 10: The results of relative permittivity a) in position of sensors, b) in whole of model.

that presented in Table 1. This parameter is considered 0.999 and it is related to urine of μ_r value. The Figure 9 presents the amount of relative of permittivity results just in bladder and this result are related to bladder condition.

The Figure 10a and b demonstrate the relative permittivity in two dimensions and in all area of model. The obtained results examine what happens in each part of the model. Two belt electrodes that are closer to the bladder are more active than two other electrodes that are far away from the bladder. The lateral parts of the shape are related to two belt electrodes, which are closer to the bladder, and the middle part of the shape is related to two electrodes that are farther away from the bladder. The relative permittivity is one of the most important parameters.

Conclusion

The Fibromyalgia is a disease that associated with chronic pain disorders and women are more likely to suffer from fibromyalgia than men. Fibromyalgia disrupts daily activity of patients and can have a serious impact on these patient's lives and work. One of the symptoms of this disease is frequent urination which results in urinary incontinence. Some of effective treatments for urinary problems are medicinal Therapies, pharmacological, non-pharmacological, and

alternative therapies include the use of protective shields, catheters, botox, catheterization, etc.

The goal of this work is design a non-invasive system to prevent the self-urinary disorders in patients particularly with fibromyalgia. The Comsol multiphysics software is used to simulate the bladder, ureters, urethra, belt and four sensors. Furthermore, the goal is to measure the increasing of the volume of the bladder and the sensors should send the alarm to the warning or indicator before the first pain threshold to informed the patient of the condition of the volume of urine within the bladder before the bladder gets out of control and the patient urinate.

In this research, the effects of electrical currents and magnetic fields have been studied and presented. We study the effects of magnetic fields and electric current include: magnetic flux density, electrical conductivity, impedance, relative permeability and relative permittivity on the simulation environment. According to the results obtained from the calculations performed on the Comsol, the obtained graphs were matched with the parameters considered in the simulation environment as well as our predictions for the results. Additionally, we understood that the magnetic field did not affect the bladder, and the two sensors embedded on the belt, which they have a greater distance from the bladder, have less effect on the bladder.

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