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ENM-PZE Interphase Sets Up the Novel Hossam's Mechanics of the Soft Tissue Healing Law of the Surgical Wound: Granted US Patents Review

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Abstract: Piezoelectric (PZE) materials are rarely used in modern medicine. They are the materials that can convert some of the mechanical stress into an electrical gradient difference (EGD). This could occur via the re-orientation of atoms inside these materials according to the rules of the electronegative momentum (ENM). It is believed that the suture materials have only one function of just an approximation of the edge of the wound till the healing is completed. Multiple US patents had been issued that changed the thinking about the repair of surgical wounds. These patents (US 9,782,513), (US 9,579,414), (US 9,849,210) claimed that the suture materials not only have to approximate the edges of the wound but also they could help in the acceleration of the healing process. The PZE materials could achieve this fundamental function via the production of the (EGD) that could be utilized by the ischemic cells at the edge of the wound to accelerate the healing process. Furthermore, they could stimulate the dormant adult stem cells in the deep layers of the wound that also help in the healing process. The acceleration of the healing process is associated with no or minimal scarring of the wound according to the Soft Tissue Healing Law. This would not only beneficial for the cosmetic purposes of the skin but also for the functional healing of the deep layers of the wound to avoid future contraction of the scar at its deep layers. Therefore, this new modality is beneficial at both the cosmetic and functional levels. Sadly, the (PZE) & (ENM) are almost unknown in the medical field by most surgeons.

Keywords: Piezoelectricity, Electronegative Momentum, Surgical Wound, Fibrosis, Scar, Soft Healing Law

1. Introduction

The surgical wounds usually heal with an ugly scar. This is only the cosmetic aspect of wound healing. This is caused by the delayed healing of wounds with excess fibrosis. However, this disfigurement is bad because it could be seen by others, the most critical damage is the soft tissues underneath the skin like the subcutaneous tissues and the muscles. The damage of deep-seated structures that lead to their fibrosis may be more dangerous than that of skin. This is because their fibrosis is associated with functional damage that may lead to a permanent disability of the muscles [1]. In the long run, the affected muscles may become shortened and much weaker. This disturbs the mechanics of the nearby joints. It is known that joint stability depends on the strength of the muscles. This may lead to osteoarthritis in the long run. The most catastrophic effect of the damage of the deep-seated structure is that it can not be corrected anymore in the future. This means the only chance for the treatment of the deep-seated lesion is at the *1st time* of the repair of the surgical wound [2]. The understanding of the rules of the piezoelectricity and piezoelectric materials of the human body could help in the faster healing of all the components of the surgical wound. These include the skin, subcutaneous tissues, and all the muscular layers down to the bone [3].

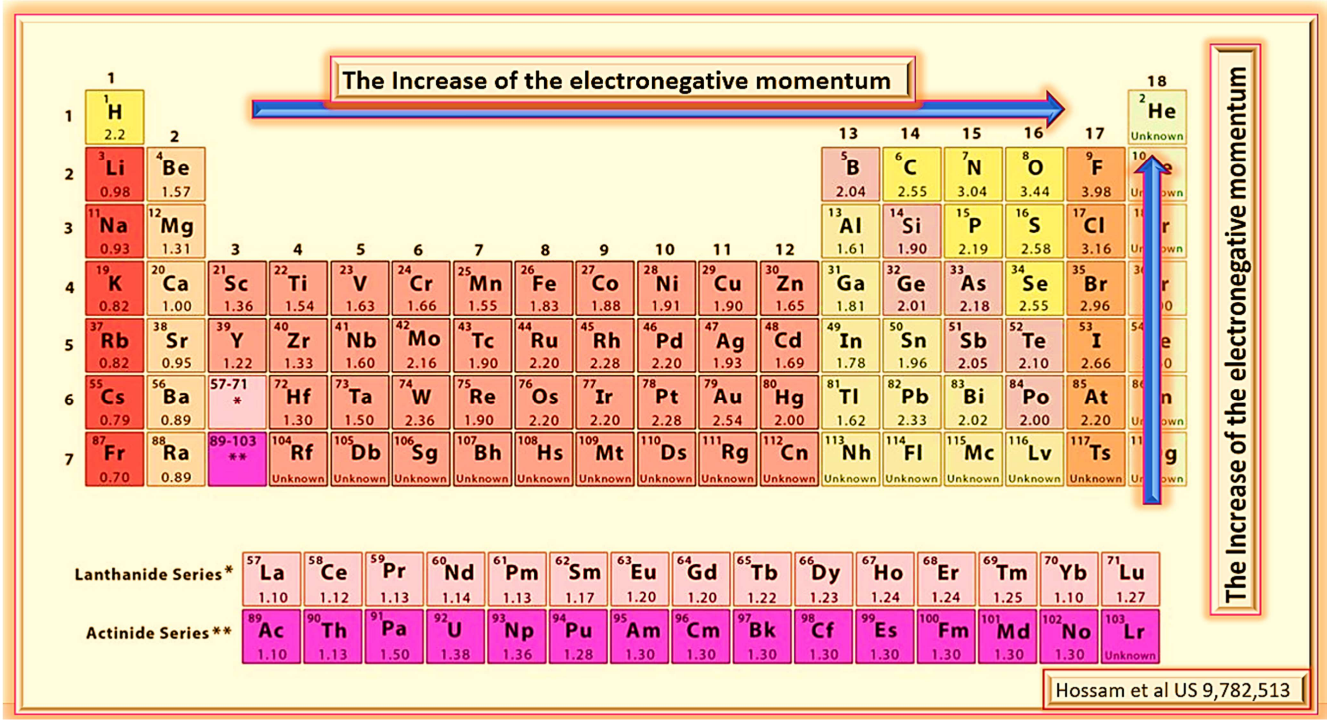

Figure 1. *The peroidic table shows that the electronegative momentum is highest at the upper and right side. Thus, the flourine atom is the highest which is (-4).*

1.1. The Electro-negative Momentum (ENM)

According to the periodic table (figure 1), each atom has a certain ability to pull a peripheral electron from another nearby atom. This is called electronegative momentum (ENM) [4]. The most electronegative atom is fluorine which is about minus 4 (-4) [5]. The higher the electronegative atoms are those of the right and upper part of the periodic table. On the other hand, the atoms on the left and lower sides of the table are considered less electronegative. This is because these atoms can easily lose the peripheral electron to the other higher electronegative atom. As the electron is negatively charged, gaining the peripheral electron causes the atom to be more negative. On the other hand, the atom that easily loses the electron becomes positively charged [7]. Examples of high electronegative atoms are fluoride, oxygen, and chloride. The commonest examples of atoms with less electronegative momentum are sodium (Na), potassium (K), Calcium (Ca), Magnesium (Mg), and most metals in general. The metals have common properties of being:

1. Shinny
2. Good conductor of heat & electricity
3. Easily, they could be shaped as wires or thin films
4. High melting temperature
5. Low electronegative momentum (easily lose peripheral electron)
6. Usually, they are present on the left side of the periodic table [8].

As said earlier, all the metals could easily lose the peripheral electron and become less electronegative. It must be noted that there is no *electropositive* momentum. It is the only electronegative momentum. Some are of high electronegative momentum e.g fluoride, chloride, and oxygen. The others are of low electronegative momentum like metals in general [6].

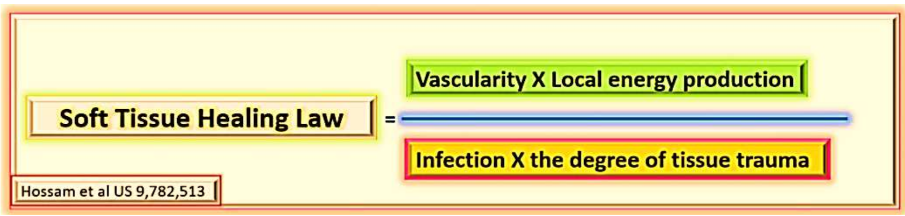

Figure 2. *The soft tissue healing law has 4 main parameters which are the vascularity, the local energy production, infection, and the degree of tissue trauma (if present).*

1.2. The Piezoelectricity (PZE)

This means that mechanical stress is converted into electrical energy. It comes from the Greek word piezo which means compression. Therefore, the meaning of this name is compression causes electricity [9]. This new modality was *not* introduced before in modern medicine. It is present in other fields like industry, agriculture, and engineering. Therefore, the subject patents of this paper (US 9782513), (US 9579414), (US 9849210), (WO2015004492) are considered the earliest ones that introduce this new modality in the surgical intervention [10-13].

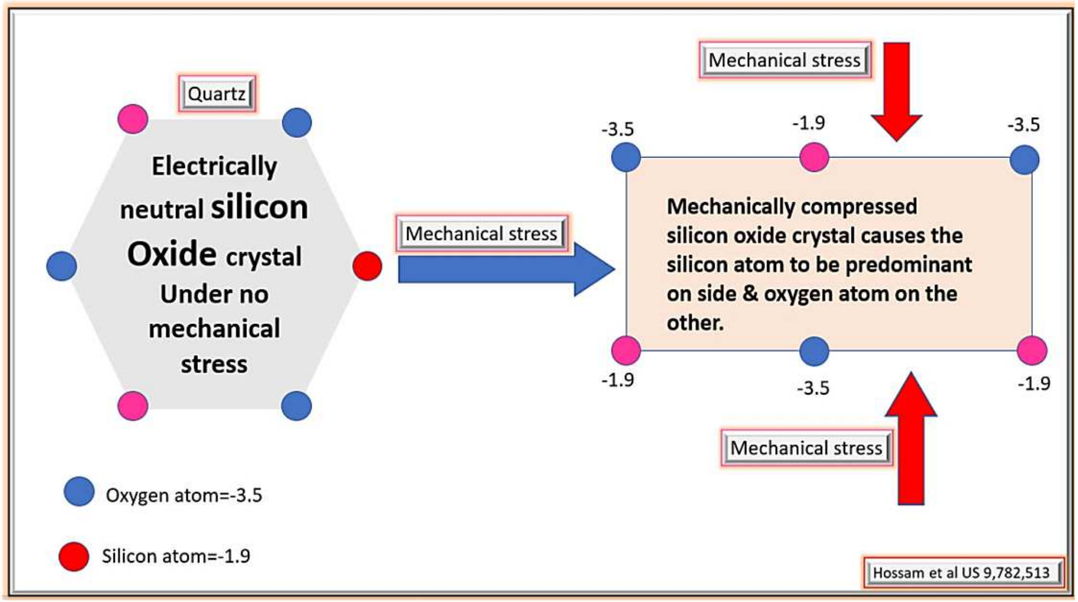

Figure 3. *Zinc Oxide as piezoelectric material. Its mechanical stress causes reorientation of its atoms. Oxygen atoms are concentrated on one side while the zinc atoms are concentrated on the oher side. This creates an electrical gradient difference due to the difference of ENM between the zinc and oxygen atoms.*

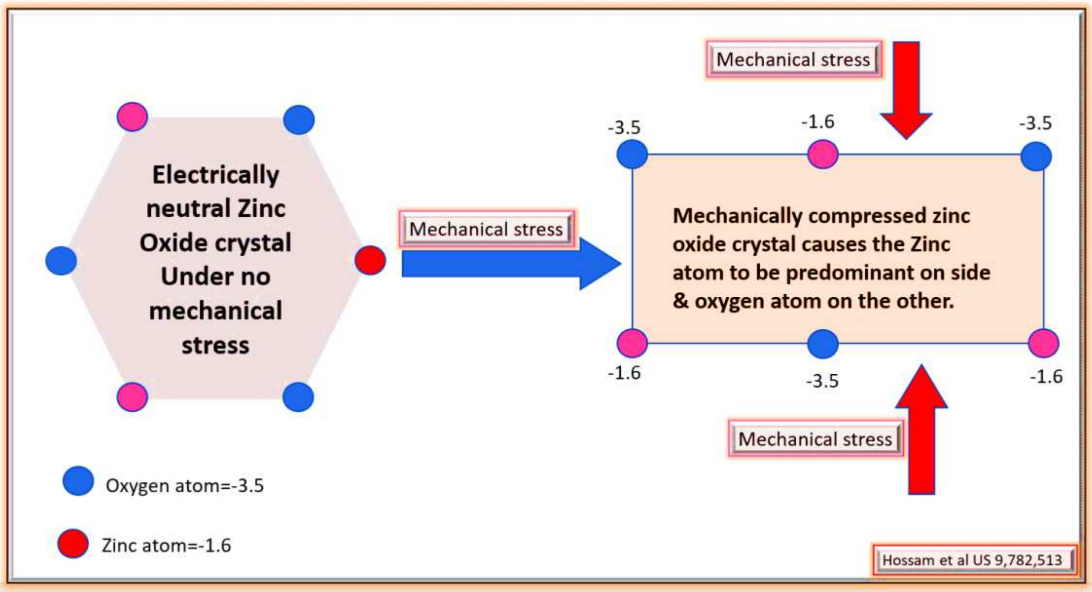

Figure 4. *Silicon Oxide (Quartz) as piezoelectric material. Its mechanical stress causes re-orientation of its atoms. Oxygen atoms are concentrated on one side while the silicon atoms are concentrated on the oher side. This creates an electrical gradient difference due to the difference of ENM between the Silicon and oxygen atoms.*

2. The Bone Is Considered the Highest Piezoelectric Structure

The bone has the highest piezoelectrical structure in the body. This means that mechanical compression of the bone causes the creation of electrical gradient difference (EGD). This could be measured electrically [14]. The question here is what is the medical importance of bone piezoelectricity?. The answer is that bone is the only tissue of the human body whose fracture heals only by bone and no degree of fibrous tissue formation is allowed [10]. On the other hand, all other tissues, if they injured, they would heal by a certain degree of fibrosis. This is presented clinically as a scar. To summarize the above point, the bone has no scar because of its high piezoelectric property [15]. All other tissues have a certain degree of fibrosis or scaring because of their lower piezoelectric property. This also means in the case of the surgical wound, it may be possible to make the surgical sutures, staples, meshes of piezoelectric materials. This may also allow the wound to heal without scarring by mimicking the bone property. This is exactly the main idea of this paper. It is known that the function of the surgical sutures, staples, and/or meshes is not to heal the wound but just approximation of the edges of the wound. Thus, the healing process would occur without a big gap which would be filled with a large scar [16]. In another word, the suture material does not only approximate the edges of the wound but also helps in the acceleration of the healing process. This could be done by supplying the ischemic edges of the wound with some electrical gradient difference (EGD). This energy could be used by wound tissue as biological energy that could help in the acceleration of the healing process. The net result is a trial to mimic the bone in its healing without scaring [17].

3. The Soft Tissue Healing Law (STHL)

The soft tissue has certain rules of its healing. The parameters of the healing depend on the vascularity of the wound, degree of local energy production, degree of infection, if present, and also the degree of tissue traumatization, if present. It is found that healing of the wound if accelerated, would heal with minimal or no scarring. On the other hand, the delayed wound healing is associated with more scar formation i.e fibrosis. The parameters that accelerate wound healing are good vascularity & more local energy production. The parameters that delay the wound healing are the local infection & the degree of tissue trauma. It is shown that not all the parameters could be manipulated or some parameters are more easily manipulated than others [18].

3.1. The Increased Local Energy Production

This is the easiest parameter that could be manipulated. It can be increased by the utilization of the suture or staples from piezoelectric material instead of normal suture or staples. The function of the normal suture or staples is just an approximation of the edge of the wound. While the suture or staples from the PZE material has 2 main functions. 1st is the approximation of the edges of the wound like that of the normal suture. Plus, the 2nd fundamental function is the supplying of the ischemic cells of the edge of the wound with energy. This could help the tissues to accelerate the healing with subsequent reduction of the amount of fibrosis. This means minimal or no scar as said earlier mimicking the bone healing [19].

The other parameter that supplies the tissue with energy is filling the pockets of the wound with materials that act as a free source of energy. The best material her glutamine-creatine-complex or (GCC). Glutamine is the commonest amino acid in the blood. It is known that 20 amino acids in the human body act as the building blocks of protein. Glutamine is the commonest amino acid in the blood and it is more than 2/3 of the percentage of the amino acid pool. The other 19 amino acids form only 1/3. This percentage shows the importance of the glutamine amino acid. Moreover, it is the only amino acid that can readily enter Kreb's cycle for free energy production. Furthermore, this is the only amino acid as 2 amine groups. i.e. (NH3). On deamination of this amino acid, these amine groups cause alkalinization that neutralizes the acidosis of the wound. It is known that the ischemic tissues of the wound show an *acidic medium* due to lactic acid produced by the ischemic tissues which may delay the wound healing. Thus, alkalinization by the amine groups of the glutamine reverses this process by enhancing the healing process. creatine also can supply the tissues of the wound with free energy production. Thus, faster healing is anticipated [20].

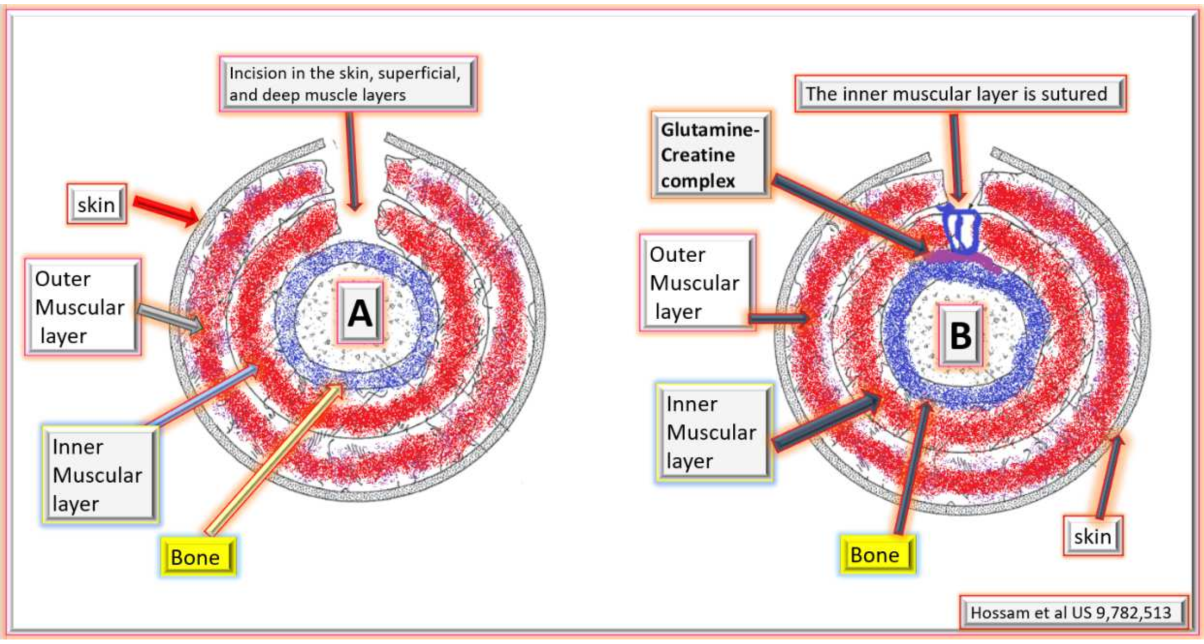

Figure 5. *On the left is (A) shows surgical wound goes deep down to the Bone. The surgical wound is in the skin, subcutaneous tissue, and the muscular layers. In the right side, picture (B), showing closure of the deepest layer of the muscle with a suture material formed of the PZE material. The pockets of the wound is filled with GCC.*

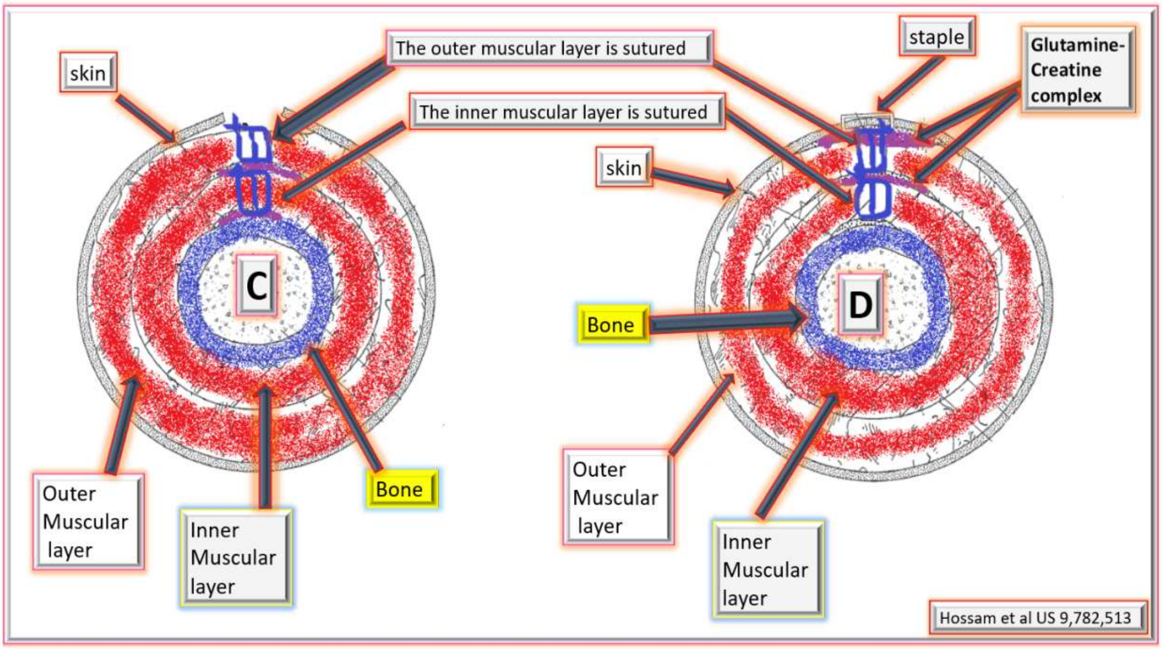

Figure 6. *In picture (C), each muscular layer is closed separately by a suture with PZE material. The pockets of the wound is filled with GCC as a free and avilable source of energy. In (D), all the layers of the wound are closed including the skin.*

3.2. Enhance the Vascularity of the Wound

The tissue damage of the wound causes ischemia of the edges of the wound due to the thrombosis of the blood vessels of that edge. Thrombosis has a protective mechanism that prevents the patient from bleeding to death. Later, the thrombosis delays the healing of the wound. The above patents tried to solve this problem via the application of infrared (IR) laser to the wound every other day. This energy causes vasodilation of the blood vessels of the area of the wound with subsequent faster wound healing and reduction of the degree of fibrosis. Recent studies show that the piezoelectric materials could retain the photonic energy from the infrared (IR) laser. Then, it re-emits it slowly over 48 hours. This means that irradiation of the wound with (IR) laser could be every other day. This is very enough to supply the wound with energy that helps it for faster healing. This also means that it gives the wound less chance to make the granulation tissues that will become later fibrous tissue or consolidate as scar tissue [21].

3.3. The Reduction of the Tissue Trauma

As can as possible in doing the surgical wound, it must be done meticulously either in the incision, handling of the tissue, or even in the repair and suturing. Every effort has to be exerted to delicate handling of the tissue. As any trauma is associated with a reduction of wound healing and more fibrosis and scaring [22].

3.4. Reduction of the Infection

Every effort has to be exerted to avoid the infection of the wound. This could be achieved by taking care of anti-septic measures of the instruments, the operating room, and even in the surgical ward. The stay in the hospital has to be reduced to the minimum. It is well-known that hospital-acquired infection is considered a catastrophe because it usually occurs with strains that may be resistant to all antibiotics. They also could be superbugs [43]. Moreover, the utilization of antibiotics has to be reduced to the minimum [23].

4. The Molecular Mechanic of Piezoelectricity

Piezoelectricity (PZE) is the material that can convert some of the applied mechanical stress into an electrical gradient difference (EGD) which can be used for biological energy. To understand fully the (PZE), it must be carefully known the electronegative momentum (ENM) of the atom. As said earlier, each atom has a specific ENM. The ability to gain the electron is high ENM as fluoride, oxygen, chloride and the ability to lose the electron means low ENM [24]. Recent studies show that the (PZE) material must be of 2 or more types of atoms with different ENM. At rest, the PZE material is electrically neutral. On application of mechanical stress, the atoms move at different speeds according to their ENM. As these atoms are of different ENM, an electrical gradient difference (EGD) is created between the atoms as shown in (figures 3, 4). This could be utilized as electrical energy that can be used by the tissue as biological energy. The higher the difference in the ENM between the atoms, the more the efficacy of the PZE property [25]. Examples of some piezoelectrical materials and how they work:

4.1. Zinc Oxide

It is considered the best and highest PZE material. To calculate the PZE property, the ENM of the oxygen (O) is about (-3.5) while the ENM of the Zinc is (-1.6). Thus, the ENM is 3.5-1.6= -1.9 which is considered one of the highest PZE. Moreover, the inflammatory cells of the wound would slowly degrade the suture material from 6 months up to 11 months. This would release the 2 components of the suture in the would. The oxygen is used by the tissue. Zinc has a great effect on the healing of the tissues it causes:

1. Epithelization of the skin
2. Anti-inflammatory effect
3. Antibacterial effect
4. Enhance the collagen formation which causes the healing to be strong [44].

Its mechanism of action is that all oxygen atoms move together at the same speed. While the zinc atoms move at another speed. This means that 60% of zinc atoms are on one side while the other 40% of the atoms are on the other side. The reverse occurs in oxygen atoms. The side of the oxygen becomes electrically negative relative to that of the zinc side which becomes relatively positive. This is because oxygen is more electronegative momentum than zinc (figure 3) [26].

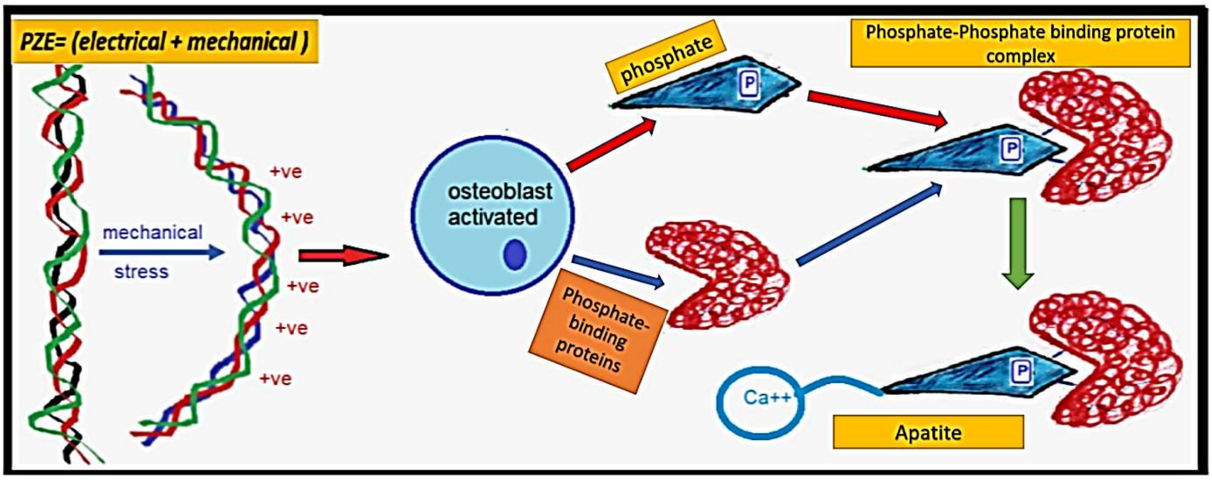

Figure 7. *Mechanical stress of the functional collagen stimulates the osteoblasts to secret both the phosphates & phosphate binding proteins. This acts as the seats for the calcium ions to build the apatites.*

4.2. Silicon Oxide (The Quartz)

This has a piezoelectric property. It is less commonly used than zinc oxide. This is because it is difficult to be manipulated as sutures or staples. Moreover, it is easily fractured. Furthermore, it is very expensive. It is formed over millions of years via the compression of silicon with oxygen. Its mechanism of action is that all oxygen atoms move together at the same speed. While the silicon atoms move at another speed. This means that 60% of silicon atoms are on one side while the other 40% of the atoms are on the other side. The reverse occurs in oxygen atoms. The side of the oxygen becomes electrically negative relative to that of the silicon side which becomes relatively positive. This is because oxygen is more electronegative momentum than silicon (figure 4) [27].

4.3. Aluminum Oxide (Ceramic)

It is not recommended to be used as the debris of aluminum would be released into the tissues. This may occur as the inflammatory cells attack the suture. Aluminum debris is toxic to the tissues. It acts as heavy metals poisoning. However, it has a high piezoelectric property, it is not advised to be used. Its mechanism of action is that all oxygen atoms move together at the same speed. While the Aluminum atoms move at another speed. This means that 60% of Aluminum atoms are on one side while the other 40% of the atoms are on the other side. The reverse occurs in oxygen atoms. The side of the oxygen becomes electrically negative relative to that of the Aluminum side which becomes relatively positive. This is because oxygen is more electronegative momentum than Aluminum. This is very similar to the above 2 examples: zinc oxide and Quartz [28].

4.4. Polyvinylidene Fluoride (PVDF)

It is as polymers. It is an excellent material because it is inert. It does not react with the tissue. The sutures are permanent and can not be dissolved by the inflammatory cells. It is strong and is recommended to replace the lost pieces of supportive structure like the stem of the artificial joints or the nailing systems of bone fracture. It is known that all bone near the area of artificial joints or metallic fixation is associated with localized osteoporosis. This means the area nearby to the bone show loss of the bone mass and becomes weak and liable to be fractured. This phenomenon is called *stress shielding* [45]. The possible explanation is that stress is transmitted in the metals faster than in the bone. Thus, the bone is deprived of mechanical stress. Thus, it shows faster resorption than new bone formation. The result is local osteoporosis and the liability to bone fracture nearby the metallic area. This would not occur if the metals are replaced by PVDF. This material is strong, has some degree of shock-absorbing, and more importantly, it is PZE. Therefore*, it can supply the nearby bone of the area of fixation with electrical energy* that can strengthen the bone. The mode of action of the PVDF is understood by knowing its atomic components. It is the polymers of carbon chains that have alternative hydrogen with fluoride. As in (figure 9), each unit of the polymer is formed of 2 carbon atoms. One carbon is attached to 2 fluoride atoms of (-4) of electronegative momentum. The other carbon atom is attached to 2 hydrogen atoms of (-2.1) of electronegative momentum. on mechanical loading, all fluorine are shifted to one side while the hydrogen atoms are shifted to the other side (figure 9). This creates an electrical gradient difference between fluoride and hydrogen. This created an electrical gradient difference that could be used for supplying the tissue with the biological energy that could be used for the repair of the damaged tissues [29].

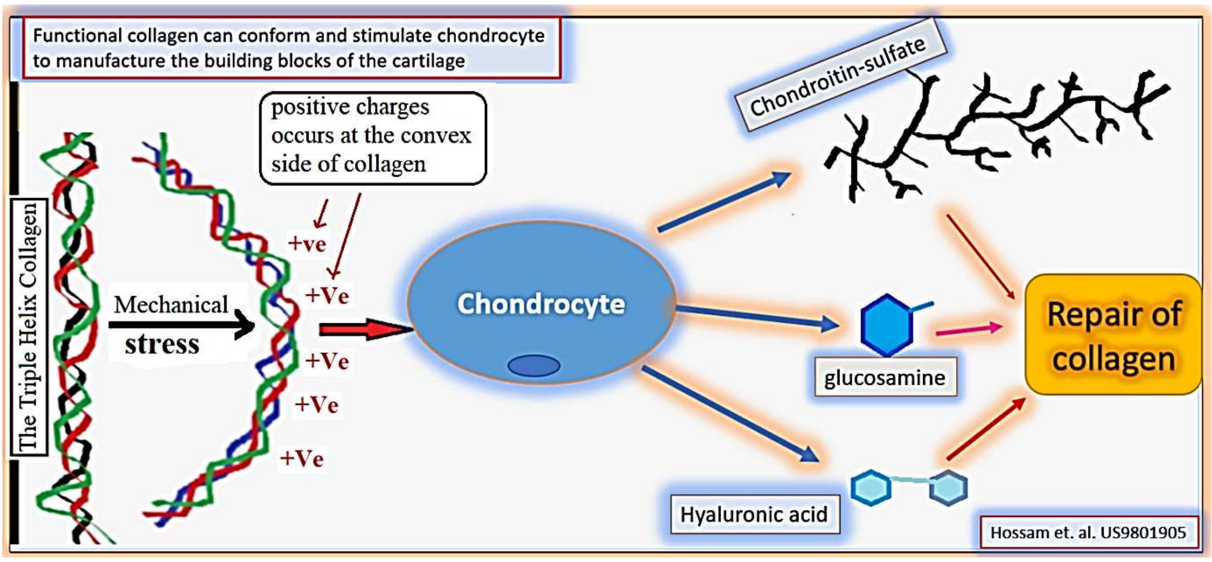

Figure 8. *The mechanical stress of the collagen of the cartilage stimulates the chondroblasts to produce all the component of the cartilage. This will lead to healing of the cartilage.*

4.5. Collagen I

Collagen is the commonest protein in the human body. It constitutes about 30% of the protein of the human body. The remaining 70% of all human proteins are about 2 million in number. This percentage may denote the fundamental importance of collagen. Collagen is only present in the animal kingdom and is analogous to cellulose in the plant kingdom. There are about 29 types of collagen. The collagen molecule is formed of the triple helix which means 3 polypeptide chains. Its folding is of alpha (α) type. 2 of them are (α1) & one of them is (α2). This means its structure is (2α1 & 1α2). Each polypeptide chain is formed of 1050 amino acids. Thus, each molecule of collagen is formed of 3150 amino acids. Collagen type I is the most important and also the most common. Collagen I forms more than 90%. It is present almost everywhere in the human body in the bone, ligaments, tendons, heart, brain, blood vessels, the skin, and even the sclera of the eye [30]. Its function as a fibrous protein was thought to be only of structural support. A granted US patent (US9801905) was issued and declared that collagen has another very fundamental function which is tissue remodeling. This simply means that the collagen, if functional, acts as a transformer that converts the mechanical stress into an electrical one. This is simply is piezoelectricity (PZE). This is of a very critical function and is responsible for the regulation of tissue remodeling. This could be achieved via the stimulation or inhibition of the surrounding cells that either build or resorb the tissue respectively. Bone remodeling by functional collagen is the best example (figure 7) [31]. The mechanical stress applied to the bone on walking or running is transmitted to the collagen of the bone. If the affected collagen is functional, it responds to the mechanical stress by converting some of the mechanical stress into an electrical one i.e. (PZE). Subsequently, the nearby osteoblasts (bone-forming cells) are stimulated while the osteoclasts (bone-eating cells) are inhibited. This simply means an increase of the new bone formation and the reduction of bone resorption. The net results are increased bone mineral density via the application of mechanical stress. It must be noted that the collagen can not do this role except if it is functional. On the other hand, the glycated collagen (dysfunctional) can not respond to the mechanical stress and bone starts to show weakness i.e osteoporosis and the liability to fracture [33]. This acts as a new concept of the pathogenesis of osteoporosis [32]. It must be noted that the collagen conformation under mechanical stress shows a positively charged convex side & a negatively charged concave side. Recent studies show that the negative charges stimulate the osteoblasts (bone-forming cells) while the positive charges stimulate the osteoclasts (bone-eating cells). This may be the possible explanation that exercise may enhance bone density. As new bone formation will be formed at the lines of the mechanical stress that is already present in the concave side (the negatively charged side) of the mechanical stress.

4.6. Collagen II

Collagen II is the 2^{nd} most important and it is less than 5% of total collagen. Its main function is in the *cartilage.* Confirmation of the collagen II of the cartilage stimulates the chondrocytes to build all the components of the cartilage. Namely, Chondroitin, glucosamine, and hyaluronic acids as in figure 8. Thus, the cartilage is repaired. On the other hand, the glycation of collagen II may be associated with idiopathic osteoarthritis. i.e the osteoarthritis that occurs in the elderly [34].

5. Discussion

PEZ is a new modality that is used in engineering and manufacturing as a source of energy production at a very limited scale. The main sources of energy production are fossil fuels, followed by the exploitation of the turbine of waterfalls, the winds, and lastly from the sun. The energy from piezoelectric materials is a relatively very small amount if compared with the previous methods. Thus, it can not support cities or industries. This new modality is not yet introduced in medicine. All the scientific papers that utilize this modality in medicine are very few and maybe less than the number of one hand fingers. The subject patents of this paper (US 9,782,513), (US 9,579,414). (US 9,849,210) are considered the pioneers to utilize this new modality in medicine. They claimed that the utilization of piezoelectric sutures, staples, or meshes could help in faster healing of the surgical wound(s). Thus, they prevent or at least reduce the scar of the wound(s) to a minimum. The amount of electrical energy produced from the PZE material is very little to support housing or industry but is optimum to support the human tissues. The tissues need a very small amount of energy to enhance their remodeling. All the prior art suture materials have one function is to just approximate the edge of the wound. In the case of the PZE suture materials, they have 2 main functions:

1. The approximation of the edge of the wounds which is similar to all the previous suture materials.
2. They have an extra-fundamental function that they supply the tissues with energy that accelerates the healing process. According to the soft tissue healing law, faster healing is associated with the reduction of fibrous tissue formation. Thus, the possibility of ugly scar formation is either prevented or limited to its minimum.

5.1. The PZE Is the Optimum Solution for the Wound Healing

The cells of the wound are desperate for energy. They have a deficiency in energy production. This is is because of the thrombosis of the blood vessels near the wound. This is a protective mechanism at the early stage of the wound to stop the bleeding. otherwise, the patient could bleed up to death. Later, the edges of the wound show manifestation of ischemia like edema or swelling of the wound. This further blocks the venous return by compression on the venous system. This causes further accumulation of the waste products at the wound edges. The cells of the wound edges show degenerative changes and some of them die from oxygen and nutritional deficiency, and also the accumulation of waste products [35]. The cells would not be able to produce energy for the maintenance of the tissue and the repair process.

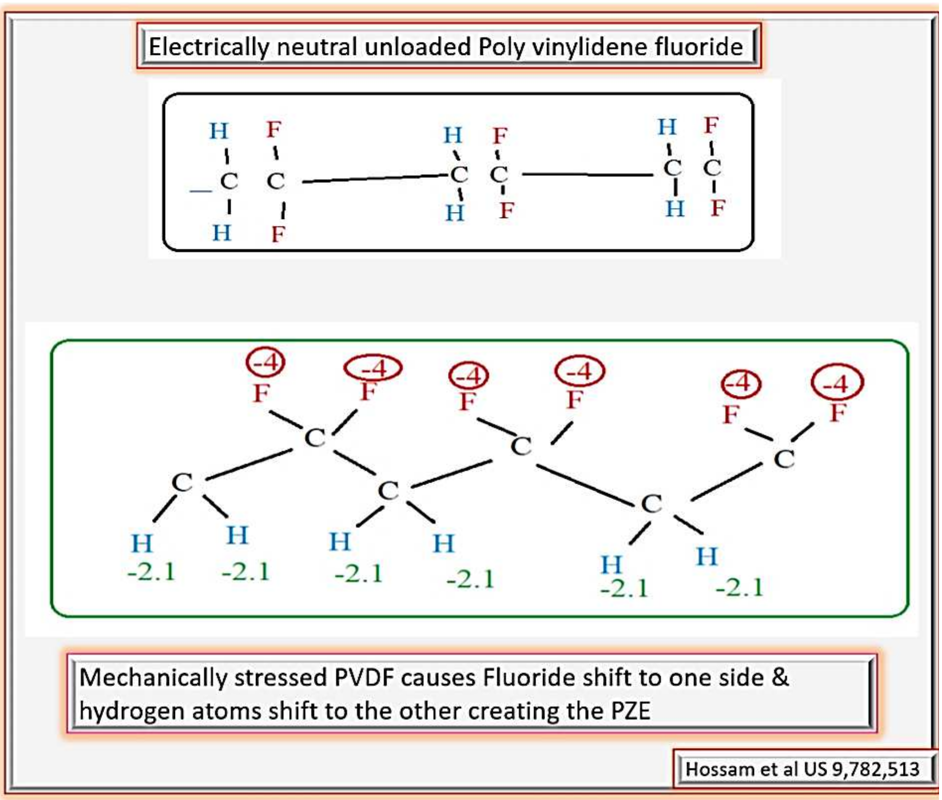

Figure 9. *Mechanical stress of PVDF causes the flourine atoms to shift to one side while the hydrogen atoms are shifted to the other side. The ENM difference between the (F) & (H) creates EGD. This could supply the tissues with energy.*

Therefore, the presence of PZE materials would give free energy to tissues. This means the whole pathological process is reversed. The affected cells receive the energy and become active again and repair the affected tissues. Thus, the healing process is expected to be fast and without scaring or at least with minimal scarring.

5.2. The PZE and Treatment of Orthopedic Degenerative Diseases

As said earlier, collagen is a building block of all parts of the orthopedic system including the bone, cartilage, tendons, ligaments, and muscles. The mechanical stress causes conformation of the functional collagen which shows electrical gradient difference (EGD) that stimulates the nearby cells to remodel the tissue. Collagen is a fibrous protein that is formed of the polypeptide chain. The peptide is a covalent bond which means it is formed amine (positively charged) and carboxyl (negatively charged). On conformation, the amine groups (positively charged) are shifted to the convex side while the carboxyl groups are shifted to the concave side. As in Figures 7 & 8. Thus, collagen shows positive charges on the convex side and negative charges on the concave side. In the case of the bone (figure 7), the conformed collagen stimulates the osteoblasts to build new building blocks of the bone substance [36]. In the case of the cartilage (figure 8), collagen II stimulates the chondrocytes to build all the building blocks of the cartilage. This will repair the damaged cartilage and causes maintenance of the healthy one.

5.3. PZE Is a Solution for the Complication of the Orthopedic Prosthesis

The application of the orthopedic prosthesis, nailing, or plates are associated with some degree of bone loss nearby the metallic materials. This phenomenon is called stress shielding [37]. This may be associated with a catastrophe which is either aseptic loosing and/or bone fracture near the metals. This needs urgent revision which is much more difficult than the 1st surgery. This is because the revision deals with a brittle bone material that is very difficult to be handled. Moreover. The soft tissues around the bone are fibrous with disturbed anatomy that is not similar to virgin tissues [38]. the molecular mechanic of this problem is that the mechanical stress passes faster in the metal than the nearby bone. This would deprive that area of the bone of its mechanical stress. As said earlier, the new bone formation depends on the passage of mechanical stress through the bone. On the other hand, the PZE materials have a modulus of elasticity of Young very near to that of the bone [39]. Therefore, the mechanical stress could still pass through the bone. Moreover, the PZE materials create an electrical gradient difference (EGD) that could stimulate the nearby bone to be increased in its intensity. Therefore, stress shielding would not occur. Subsequently, aseptic loosing would be prevented [40]. Thus, it is greatly recommended that the prosthesis, plates, and nailing of the orthopedic system be replaced with PZE materials rather than titanium which is commonly used.

5.4. PZE and Dormant Stem Cells

The PZE materials stimulation by the mechanical stress is associated with electrical gradient difference (EGD). This not only stimulates the ischemic and degenerative cells in the wound but also stimulates dormant stem cells. These cells are present deeply seated between the arterial system. Therefore, suturing of the deep layer of the wound with PZE materials causes stimulation of these cells. These cells once activated, they repair the damaged tissue with a new one similar to the original tissue without fibrosis. This is because the dormant stem cells between the deep arterial system are usually of an adult type of stem cells. These cells rapidly differentiate to blast cells that repair the blood vessels and myocytes that repair the muscular layer without fibrosis. It also stimulates the fibroblasts to secret excess new collagen. Thus, they would heal without fibrosis or at least with minimal scarring. In the case of normal suture, fibrosis of the muscles must occur. This would affect the function of the affected muscles which must be shortened and become weaker. As stability of the nearby joints depends on the strength of the muscles that work on that joint. Future instability and subsequent osteoarthritis are anticipated. All these vicious-cycle complications could be prevented by the utilization of PZE in the deep-seated area of the wound [41].

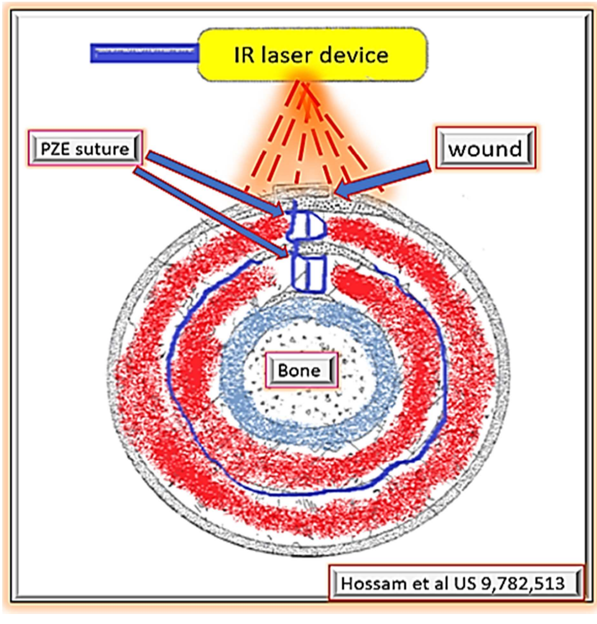

Figure 10. *Infrared laser is applied to the wound that sutured with PZE. These materials absorb the photonic energy and re-emit it very slowly to the surrounding tissues. This accelerate healing of the edges of the wound with no or minimal scar.*

5.5. The Infrared Laser (IR) and PZE

Infrared laser (IR) has a very important relation to the PZE materials. IR can supply the PZE materials with photonic energy over 20 minutes of exposure to the repaired wound.

The PZE would release this energy to the surrounding tissue over 48 hours. This helps in accelerating wound healing. As said earlier, the tissues at the edge of the wound are oedematous and ischemic. They are desperate for energy. Thus, the application of (IR) laser followed by the release of this energy to the surrounding tissue leads to the complete reversal of the causes of fibrous tissue formation. Thus, the healing of the wound would be faster and without scar or at least with minimal scar tissues [42].

6. Conclusion

The piezoelectric materials are conformed under mechanical stress. The orientation of their atoms would be changed. The new orientation creates a very mild electrical gradient difference i.e electrical energy that can be used by the ischemic tissue. Few works of literature pay attention to this new modality of treatment. This means that PZE is almost unknown in the medical field. The subject patents of this paper for the 1st time change the concept of repair of the surgical wound. The suture materials are only used to approximate the edges of the wound in all of its layers. The subject patents claimed that the edges of the wound are approximated plus PZE materials allow the wound to heal faster with no or at least a minimal scar. This suggests that the suture materials have to be replaced by the new ones that not only just approximate the wound edges but also help in the reparative process. It is also suggested that these materials may be tried in another medical field of the prosthesis, especially that of the orthopedic system. It is known that the bone nearby the metals are associated with localized osteoporosis which is known as stress shielding. If prostheses, nails, screws, and plates are replaced by PZE materials, this problem would disappear. Stress shielding is responsible for a big sector of revision surgery in the orthopedic system. It is responsible for the fractures of the bone nearby the metallic fixation and/or the aseptic loosing of the prosthesis. These are considered a catastrophe in the orthopedic world. The surgical revisions are usually more difficult than the 1st surgical intervention. In the case of revision surgery, the anatomy is disturbed by the previous surgery. Moreover, the excess fibrous tissue formation may delay the healing and even enhance infection. Thus, the solution is simple which is gradual replacement suture, staples, meshes, and prothesis with PZE materials.

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