Regenerative Medicine

By Shripriya Singh, PhD
Contributing Editor

Organ healers: Nanochips as the revolution in the field of regenerative medicine

Research and medicine are the two arms of science which have equipped human beings to surpass all other living species on our planet. On one hand research enables us to rediscover, invent and create new technology and on the other hand medicine allows treating, curing and saving lives. When technology amalgamates with medicine it spells nothing less of a miracle. Diseases that seemed untreatable a while ago are curable today and ones that were considered incurable are at least manageable today. The progress made in the world of medicine is undeniable and has changed the current face of human health. However, nature finds its own ways of challenging our existing amenities and resources. In order to combat the upcoming challenges in areas of health and medicine, researchers and medical practitioners are constantly looking for alternative remedies and potential therapies. One such challenge is the problem of organ regeneration and tissue healing.

Medical treatment not only requires the treatment of the diseased state but also involves the restoration of a patient to his/her normal healthy life. In this regard emphasis is laid on not only treatment but also healing. In certain cases of accident, traumatic injury, gangrene or septicemia, limb amputation becomes inevitable and the only means of saving a life. Such incidences not only cripple the patients but also have long lasting debilitating effects on their physical and mental wellbeing.

There has been an upsurge in the field of stem cell biology in the last two decades and it has revolutionized the world of medicine and therapeutics. Stem cell

based research is synonymous with regenerative medicine, organ transplantation therapeutics and drug development. Stem cells are unique in their ability of self-renewal, differentiation and can be directed towards a particular lineage conversion. Therefore it is clear that there is some dormant genetic machinery which can be triggered and activated by a stimulus and thus stem cells are manipulated to differentiate into a tissue or organ-specific lineages. Pioneer work by Yamanaka *et al.* in 2006 further proved that this stem cell differentiation is reversible and by controlling select transcription factors normal adult fibroblasts can be converted back to stem cells, which gave us the concept of induced pluripotent stem cells or iPSCs [1]. Overall the crux of stem cell uniqueness is housed in the stem cell genome. Therefore by manipulating the genetic transcription machinery and molecular switch it is possible for the scientists to decide the fate of a particular cell in the body. This kind of tissue reprogramming offers endless possibilities in the field of tissue regeneration, organ transplantation, limb restoration and healing.

Fast paced, one touch healing devices sounded like science fiction a while ago, but no longer!!!Thanks to the advances made in molecular biology, nanotechnology, stem cell biology and electronics we have a solution that was never earlier imaginable. A breakthrough Nanochip can heal injuries with just a single touch. Researchers at the Ohio State University have developed a novel technology which allows body to regenerate any type of cell through genetic reprogramming and this could lead a medical revolution in how we treat injuries and organ regeneration [2].

What is the Nanochip capable of? The technology and innovation involved:

The nanochip is a simple yet unique miniscule device designed around the novel concept of tissue nano-transfection (TNT). TNT is an electroporation based technique that facilitates the direct delivery of reprogramming factors (DNA) into the cytosol via the application of a focused and highly intense electric field through arrayed nanochannels. The electric field benignly nanoporates the cell membrane and the reprogramming factors are electrophoretically driven in [3, 4]. The process involves placing a finger nail sized nanochip (containing the required genetic material) on the patient's skin and zapping it with an electric current which drives the DNA through the nano channeled device into the skin cells. Thus the patient's own skin tissue acts as a bioreactor and the skin fibroblasts are genetically reprogrammed into specific type of cells that can be used in other parts of the body for grafting and healing purpose. The process of DNA delivery takes less than a second and the nanochip can be removed thereafter. This technique is by far the simplest, non invasive, topical, viral free deterministic tool of *in vivo* gene transfection and cellular reprogramming (Figure 1) [5].

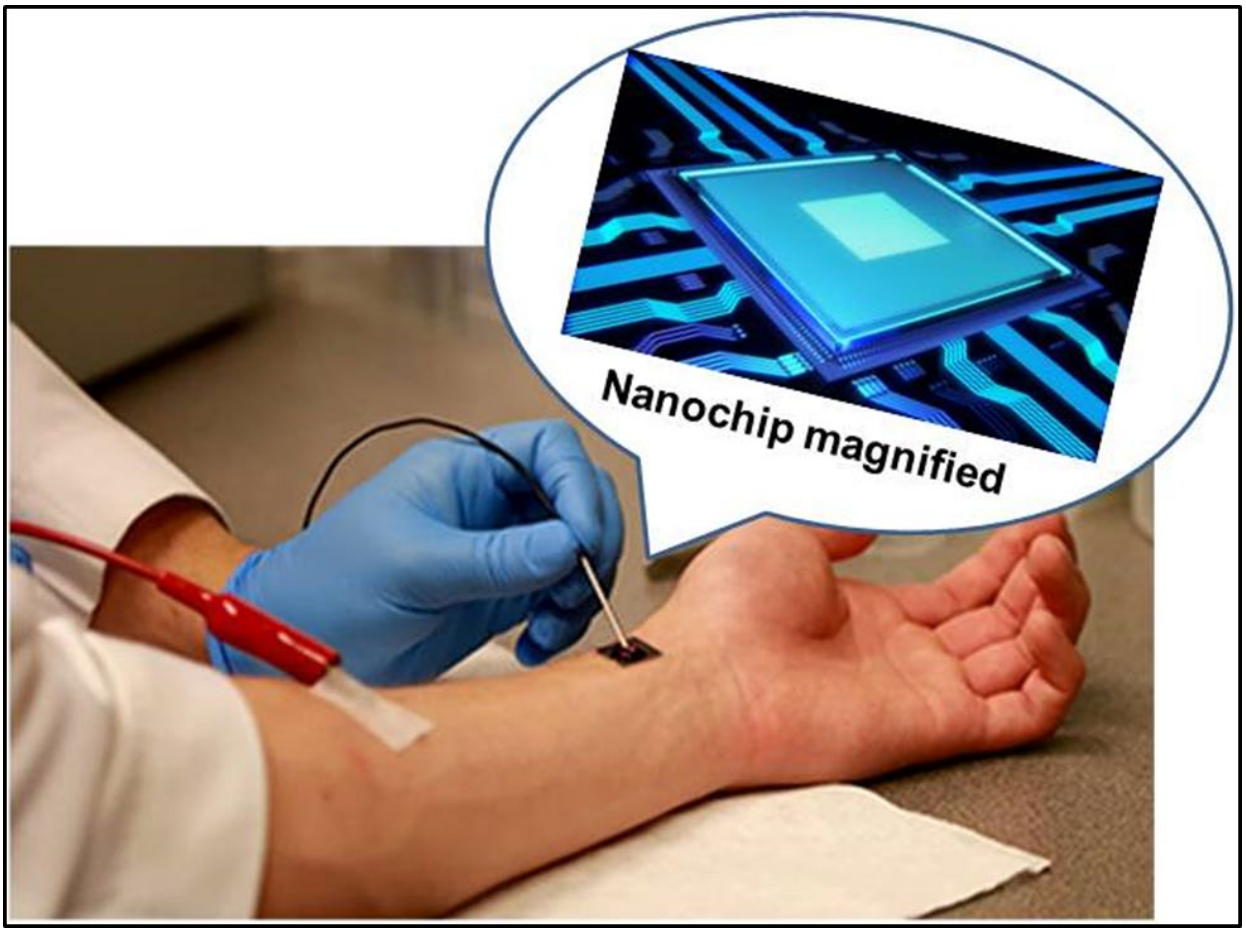

*Figure 1. Concept of the fingernail sized nanochip's direct application on patient skin for cellular reprogramming and tissue healing. [**Source:** Human Regeneration, 2017]*

The technology was initially tested on murine models. In one case the skin cells were successfully reprogrammed into neurons and formed new nerve cells in the legs of brain damaged mice. The induced neurons were then harvested and injected into the mouse brain to help with stroke recovery. Another experiment was conducted on a mouse with a severely injured leg, the skin cells were successfully reprogrammed into vascular endothelial cells and angiogenesis was observed which led to the formation of new blood vessels (Figure 2). The result was a successfully healed limb within two weeks of the application of the nanochip. Thus the technology successfully rescued necrotizing tissue and whole limbs in the murine models of brain damage and injury-induced ischemia [2]. The experiments when duplicated on pigs also furnished fruitful results. The technology is still in its nascent stage and human clinical trials are yet to begin.

*Figure 2. The organ healing potential of the nanochip device. [**Source:** https://www.knobbe.com/news/2017/08/nanochip-device-potential-heal-tissue-and-organs Original article source: Nature nanotechnology, 12(10):974. 2017]*

Once approved, The Walter Reed National Military Medical Center in Bethesda, Maryland, shall run the human trials.

The future prospects

The uniqueness of the technology lies in the fact that it can switch tissue function within the live body in the presence of immune surveillance of the patient itself and can produce autologous cells to rescue tissue damage locally or distally upon harvesting without eliciting any adverse immune responses. The beauty of the technology is envisaged in the fact that it requires no laboratory based procedures and can thus be directly used by medics in a war field, in an emergency room or even the doctor's office directly. If successfully tested in humans the technology holds potential to replace many surgeries, provide limb salvaging, prevent amputations and regenerate organs.

Since the technique can potentially regenerate the damaged brain tissue it could be the next possible therapy for the incurable neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, amyotrophic lateral sclerosis and Huntington's disease. The technology is also being looked upon as

the next medical revolution in the field of transplantation therapeutics and organ grafting. The nanochip can rescue the normal functioning of damaged organs and can restore the youthful functioning of aging hearts. The technology is speculated to become an indispensable amenity for military forces of the world where soldiers are in constant need of medical miracles. The technology can be used for treating military wounds and injuries and can be used as an effective treatment for traumatic brain injury and brains damaged by post-traumatic stress disorder. It is not farfetched to believe that the nanochip one day might speed up the healing process of fractured bones, wrecked vertebrae, sprained joints and ruptured spinal discs, thus changing the current face of orthopedics tremendously. Although still in its infancy the TNT based nanochip technology has shown promise and has unlocked limitless avenues in the field of regenerative medicine and organ healing. Thereby we optimistically conclude that if the research stands the test of human clinical trials successfully we are not very far away from achieving a medical and scientific milestone that sound miraculous today but will become a reality of tomorrow.

References

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