Plastic Surgery and Nanomedicine Relationship

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Abstract

Plastic and reconstructive surgery is one of the surgical subspecialties with the widest range of specialties. Grafts, flaps, free-tissue transfers, and replantation of various tissues, such as nerve, vascular, bone, muscle, and skin, are among the techniques used. Plastic surgery aims to maintain or improve the aesthetic appearance of the treated area while restoring the form and function of removed or damaged tissue. By upholding these principles, the plastic surgeon can help the patient enhance their quality of life. Biological activity is generally considered less during surgical treatments and primarily focuses on mechanical tissue healing.

Keywords: Plastic surgery • Nanomedicine • Nano-array

Introduction

Despite significant technological gains and advances in surgical technique, there are still many faults and injuries that could benefit from stimulation of the underlying tissue biology to speed recovery. Reconstructive surgery may benefit greatly from interaction with other scientific domains, such as bio- and nanomaterials. Nanomedicine is unique in that it enables researchers to have an impact on molecular targeting and repair due to the small size of the materials used [1]. These materials have the advantage that the building blocks can stimulate cellular repair in the body because of their size and composition. In order to replace or repair missing or damaged native biologic structures in the human body, it is important to develop nano- and biomaterials with the appropriate architectures and compositions. Biomimetic materials have recently been developed as a novel method to elicit tissue response without the use of a bioreactor, despite the fact that the traditional tissue engineering paradigm includes polymeric scaffolds, co-cultured cells, growth factors, extracellular matrix components, and other bioactive molecules, all of which are integrated into a bioreactor [2]. The goal is to create nano- and biomaterials with structures and makeups that can restore or replace lost or damaged native biologic structures in the human body.

Although the traditional tissue engineering paradigm uses polymeric scaffolds, co-cultured cells, growth factors, extracellular matrix components, and other bioactive molecules, biomimetic materials have recently been developed as a novel way to elicit tissue response without the use of a bioreactor [3]. Future regenerative and restorative medicine may greatly benefit from a hybrid approach that restores damaged tissues using both mechanical reconstruction and biomimetic materials.

Mandibular reconstruction may be required to correct anomalies brought on by oncologic excision or trauma. Depending on the location and size of the mandibular defect, several reconstruction techniques are used. Typically, lesions less than 6 cm are repaired with vascularized bone. The free fibula osteocutaneous flap is the go-to donor source for mandibular repair because of its length, compatibility with endosteal implants, and potentialfor skin islands if soft-tissue restoration is necessary. The use of Computer-Aided Design/Computer-Aided Manufacture (CAD/CAM) has been shown to improve function, morphology, and accuracy for challenging segmental mandibular restoration when compared to conventional free-hand techniques [4,5]. Two of the most important goals in mandible restoration are mechanical stability with accurate bone replacement and osteointegration at the contact sites between the native and rebuilt mandibles. CAD/CAM has increased the accuracy of exact bone replacement, however aside from more precise bone to bone contact, it has minimal impact on osteogenesis or osteointegration. A general strategy to regenerative medicine in the context of mandibular restoration comprises physically mending the initial defect and integrating the graft through enhanced vascularization, with the ultimate goal of restoring shape, function, and innate biological activity.

In an effort to repair large lesions in the jaw, researchers have already started looking into a nanomaterials approach to bone regeneration, although prior research indicates that the bony matrix does not appear to use exogenous growth hormones well. In the absence of nanotechnology, BMP2 (Bone Morphogenetic Protein-2) was used to aid in the stimulation of bone growth, but it had devastating adverse effects such as cancer, spinal cord compression (due to swollen soft tissues), ectopic bone formation, increased bone resorption from excessive osteoclast activation, and induction of adipogenesis instead of the desired osteogenic process.

Nanotechnology can offer a more complex method, ensuring that the regenerated bone is functional and associated with the original structure of the bone by seeding a scaffold with polymeric nanoparticles to facilitate effective vascularization and innervation. It is possible, for instance, to immobilize BMP-2 using a gold nano-array, enabling a controlled release of BMP2 during the bone-regeneration process while limiting adverse effects. We may therefore be able to disseminate these signaling molecules in a controlled geographic and temporal manner by seeding the scaffold with signaling components.

By having more control over the regeneration process, plastic surgeons would be able to guarantee adequate vascularization and structure. Not only could chemical release be modified, but the implant could also be made to release certain components at precise spatial locations of the implanted scaffold in order to trigger the cellular response needed there. One or more tissues, such as elastin, type I collagen, or hydroxyapatite, may be employed to create the scaffold. Components of the scaffold provide mechanical and chemical cues that urge body cells to go to the healing site and differentiate into bone. By focusing on the biological mechanism of tissue repair and optimizing vascularization, the regenerated bone will be optimally integrated within the native tissue, enabling function and form to be significantly better than current mandibular reconstruction treatment options. The scaffold will also be precisely shaped to fit the patient's natural contour.

One of the most popular techniques used by plastic surgeons to repair burns is the use of skin grafts, either Full-Thickness Skin Grafts (FTSG) or Split-Thickness Skin Grafts (STSG). Skin transplant survival is dependent on the recipient site's vasculature and ability to undergo angiogenesis since skin grafts are removed from the donor site without a blood supply. In contrast to STSG, which includes the epidermis and various layers of the dermis, FTSG includes both the epidermis and the dermis. FTSGs are limited to minor faults because the donor site must first be sealed. Even though auto-grafts are the gold standard for skin healing, larger lesions often leave insufficient tissue for their use. STSG can, however, cover more atypical conditions because the donor site is left with dermis components to healing later. Additionally, the STSG may withstand more contraction and color changes than FTSG, making it a preferable treatment.

Multiple low-level tissue engineering projects have to utilize cultured expanded cell lines of autologous keratinocytes. These can then be

"re-applied" in a number of different ways to the wound. These methods have the disadvantage of being constrained in thickness, lacking structural stability, and lacking dermis and adnexal tissues. Early attempts to create a skin substitute via bioprinting are still being made, although they share many of the same shortcomings. These processes are outdated in comparison to current tissue engineering capabilities, and combining bioprinting and cell growth technology incurs significant costs. One major limitation, for instance, is whether enough cells can be speedily generated to bioprint the necessary skin constructs. Utilizing nanoscale materials has the benefit of accelerating and improving wound healing by activating the body's internal repair processes.

As readily available commercial skin substitutes, synthetically produced polymers are used. Materials that were created ex-vivo or from a source other than the patients themselves are referred to as synthetically generated polymers. These skin replacements are composed of porcine and bovine collagen, shark chondroitin, cadaveric dermis, newborn foreskin, Cultured Autologous Epidermis (CAE) keratinocyte sheets or cell spray, and fibroblasts seeded onto a 3D scaffold generated from hyaluronic acid or synthetic polymer membrane. These solutions, despite containing natural ingredients like hyaluronic acid, have drawbacks including insufficient vascularization, an inability to integrate, scarring, and immunological rejection because they incorporate multiple skin substitutes. Additionally, they call for the patient to move very little during therapy, which is not always possible.

In contrast, natural polymers might work better in the clinic because they are more biocompatible, have lower immunogenicity, and can eventually be resorbed as newly deposited tissue is repaired. Last but not least, earlier work in nanomedicine led to the creation of nanoscale films that can detect stresses and mechanical stimuli acting on the skin. The spatiotemporal mechanical properties needed for skin regeneration might be monitored and recorded using these films.

Additionally, the use of a film may be used to monitor the healing process as it occurs during the regeneration phase, enabling customized medical or surgical treatments. For instance, if the film showed that a patient was healing a skin wound more slowly than expected, extra pharmacological therapies could be injected to hasten the healing process. By accident, nanowires have a high level of sensitivity, which enables them to offer crucial tunability for skin regeneration. Doctors could fine-tune the healing process and get better results by using these films in plastic surgery since they could watch the healing process in real time.

Conclusion

Although plastic surgery has come a long way, there are still numerous ways it could be improved. By using nanomedicine techniques, surgeons may be better able to restore function and produce better results. The ability to combine the talents of tissue engineers, biologists, material scientists, and plastic surgeons will make it possible in the future to build materials, implants, and drug-eluting nanoparticles that can be quickly transported to the clinic. The more pre-clinical investigation is required to better comprehend how to use nanomedicine in the field of plastic surgery. By cooperating with experts from other professions, plastic surgeons will eventually be able to change and advance the industry.

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