Editorial

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The Evolution of Urogenital Tissue Engineering

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In Boston in 1954, Hartwell Harrison, the chief of urology at Harvard University, harvested a kidney and performed the first ever human organ transplantation [1]. The concept of cell transplantation developed after kidney transplantation and led to the first human bone marrow cell transplantation in the 1970s. At that time, researchers combined the scientific fields of device and material sciences with cell biology and in effect pioneered a new field called "tissue engineering" [2]. The first use of the term "tissue engineering" can be traced in the literature to a reference dealing with corneal tissue in 1985 [3]. The discovery of mouse embryonic stem (ES) cells in the early 1980s gave a huge boost to the stem cell field and led to the description of human ES (hES) in 1998 [4]. The creation of the first cloned mammal, a sheep named Dolly, was announced in 1997 [5]. Two years later, the term "regenerative medicine" was coined to describe the unifying goal of cell transplantation, tissue engineering, and nuclear transfer, i.e., the regeneration of living tissues and organs [6]. Over the past decade, the number of patients waiting for transplantation has doubled, while the actual number of transplantations has remained practically unchanged. This disparity is a consequence of our aging population. As time passes, we get older and older, and medicine does a better job of keeping us alive. However, as we age, our organs tend to fail more often. This, then, is our new challenge. Although advanced medicines and treatments have saved many lives, we now face a major shortage of organs. The human body has many organs, each of which has a cell population that is ready to take over at the time of injury. It happens every day of our lives. Thus, our body is constantly regenerating. When challenges occur through an injury or a disease, the human body's first reaction is to seal off the area. Whether it is the organs inside the body or the skin, the development of scar tissue is the immediate response to solve the problem. How can we harness that power? One way is through the use of smart biomaterials. In 1996, the first use of natural biomaterials in humans for tissue regeneration demonstrated that smart biomaterials could be used as a bridge in the treatment of an injured urethra [7]. First, the injured area was closed off from the outside environment. Then, cells that were regenerated in the body crossed the bridge and followed the pathway or channel that connected to the bladder or to outside the body. Tissue engineering for urethral reconstruction may involve matrices alone, wherein the body's natural ability to regenerate is used to orientate or direct new tissue growth, or the use of matrices with cells. Acellular collagen matrices that are derived from donor bladder submucosa have been used both experimentally and clinically for urethral replacement. Urethra successfully regenerates, but only over a limited distance. What if the injury is in a larger organ? What can we do to repair injuries in structures that are much larger than the limited distance of regeneration? Researchers have turned to cells to solve these problems. The strategy is to take a very small piece of tissue from the injured or diseased organ and to tease that tissue apart into its basic components. Then, the patient's own cells are taken and grown outside the body in large quantities. Next, scaffold mate-

rials are used. The scaffold acts as a cell delivery vehicle, bringing the cells into the body and allowing them to regenerate into new tissue. Scaffold materials are designed to disintegrate in the body a few months later. Currently, gastrointestinal (GI) segments are commonly being used as tissue for bladder and urethral replacement or repair. However, GI tissue is designed to absorb specific solutes, whereas bladder and urethral tissue are designed for the excretion of solutes. When GI tissue comes in contact with the urinary tract, multiple complications may occur, such as infection, metabolic disturbances, urolithiasis, perforation, increased mucus production, and malignancy [8]. James J. Yoo, the Associate Director of the Wake Forest Institute for Regenerative Medicine, focuses his work on growing and regenerating tissues and organs. His team engineered the first lab-grown organ to be implanted into a human - a bladder. His article 'in this issue of the Journal' [9] will introduce the novel tissue engineering-based regenerative strategies that are being applied to bladder reconstruction and will discuss how these strategies can be used to treat the neurogenic bladder.

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