Commentary

iMedPub Journals
www.imedpub.com

Medical and Clinical Reviews
ISSN 2471-299X

2022
Vol.8 No.8:002

Medical Application of Microfluidic Devices in Orthopedics

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Received date: July 04, 2022, Manuscript No. IPMCR-22-14518; **Editor assigned date:** July 7, 2022, PreQC No. IPMCR-22-14518(PQ); **Reviewed date:** July 20, 2022, QC No IPMCR-22-14518; **Revised date:** July 27, 2022, Manuscript No. IPMCR-22-14518(R); **Published date:** Aug 05, 2022, DOI: 10.36648/2471-299X.8.8.2

Citation: kevin B (2022) Medical Application of Microfluidic Devices in Orthopedics. Med Clin Rev Vol. 8 Iss No.8:002.

Description

With the development of modern medicine, the research methods of occurrence, development and treatment of orthopedic diseases are developing rapidly. The microenvironment provided by traditional orthopedic research methods differ considerably from the human body, resulting in poor or inconsistent conclusions in previous studies. Microfluidic technology has shown its advantages in the field of orthopedic research, especially in providing bionic mechanical stimulation environment. The microfluidic device can simulate the complex internal environment through the fine and complex structure and perfusion control system, and provide a stable, controllable and efficient culture system. Moreover, it can serve as a manufacturing device, which can produce bone grafts or bone like organs for tissue engineering with bionic structure. It can also simultaneously act as a detection device, which can realize high-throughput detection of small samples at low cost. In addition, we can establish *in vitro* physiological or pathological models on microfluidic systems to assist in the diagnosis and treatment of orthopedic diseases. This paper reviews the medical application of microfluidic devices in orthopedics. As the most prevalent hard tissue in the human body, the bone bears the functions of movement and body support. Its growth, development, and remodeling are closely related to the mechanical stimulation.

Relationship between Force and Bone Tissue Behaviors

However, the studies on the relationship between force and bone tissue behaviors have mostly relied on clinical observations rather than experimental investigations. As a type of tissue with a complex three-dimensional (3D) structure and diverse cell types, the bone tissue works with many other organs in the human body. The conventional research platforms that have mostly relied on static anatomy and cultures cannot reflect the actual internal environment, causing varying levels of inaccurate or inconsistent experimental data. With recent technological advancements, various devices have been developed to reproduce these complex microenvironments for orthopedics research. Particularly, microfluidic devices have drawn considerable attention. Microfluidic devices are gradually applied in areas such as chemistry, chemical engineering, and health care. Thanks to the characteristics of the microfluidic devices, tiny fluids as well as fine 3D structures can be well manipulated using micro channel platforms. This is an emerging interdisciplinary subject involves chemistry, fluid physics, microelectronics, new materials, biology, and biomedical engineering. Because of their miniaturization and integration, microfluidic devices are often referred to as microfluidic chips, or known as Lab on a Chip or micro total analysis systems. The earliest devices based on microfluidic concepts are the gas chromatographs fabricated on silicon wafers using lithography in the 1970s, which were then developed into microfluidic capillary electrophoresis and micro reactors.

Microfluidic Perfusion System

Among the important features of microfluidics are their unique fluid properties in microscale environments, such as laminar flow and droplets. With these unique fluid phenomena, microfluidics can achieve micromachining and micromanipulation, which are difficult to accomplish with a range of conventional methods. The human body is composed of various orchestrated microenvironments, specific to the local, in which various cavities and pipes are staggered. Overall, the body is a combination of various organs. A microfluidic device integrates various precise structures generated by micro fabrication to simulate micro-units of various organs, and then connects various units to simulate the cooperation among the various organs. The microfluidic perfusion system is capable of simulating the environment in the body and converting static cell culture into dynamic life culture. For orthopedics, one of the great advantages of microfluidic device is the ability to provide mechanical stimulation of fluid flow. By designing various types of fluid chambers, the cells are subjected to fluid stimulation with well-defined parameters such as size, direction, and frequency.