polyMed Pump: Self-Powered Polymer Muscle-Activated Streaming Therapy

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Abstract

The polyMed Pump, a patent pending self-powered “polymer muscle-activated” medical-grade pump is a new advance in woundcare treatment and drug delivery. PolyMed is a completely new innovation in chemotherapeutic delivery to promote wound healing. Polymed is the first ultraportable infusion pump worldwide to offer performance, safety, disposability, comfort and flexibility without any electrical power. The polyMed pump features “multimodal streaming” capability to provide real-time streaming therapy. It can be used in a wide range of therapies e.g. oncology, wound chemotherapy, wound irrigation, pain treatment, antibiotics, corticoids, hormones, anti-epileptics, spasamolytics, cardiology, tissue positioning/separation, and medical adhesive sealant dispensing.

Background

Diabetes and wound-related complications around the globe results in one major limb amputation every 30 seconds, over 2500 limbs lost per day. Foot problems in patients with diabetes mellitus are a major public health concern in the United States. Nearly 24 million people in the US have diabetes. Foot ulcers develop in about 15% of patients with diabetes. The lifetime risk of a person with diabetes developing a foot ulcer is as high as 25%. Up to 70% of all leg amputations in the United States are performed on people with diabetes and approximately 85% of lower limb amputations in patients with diabetes are preceded by foot amputation. Therefore, there is a need for a innovative strategies for treating wounds and promoting wound healing.

Methods

The innovative pump design incorporates two types of hydrogels, the superporous hydrogel (SPH) for pump actuator, and an environmentally-sensitive N-isopropylacrylamide (NIPAAm) hydrogel to trigger pump operation. Two types of SPH polymers have been investigated for possible use as a pump actuator: 1) a SPH polymer with additional monomer (0.8771%) and 2) a superporous hydrogel with an interpenetrating polymer networks (IPN), is referred to as SPIH, incorporates a second polymer network inside of an SPH to strengthen the polymer structure. See Figure 1 for SEM photo of SPH and expanded action(Fig 2).

Results

The polyMed pump will be designed to dispense the therapy fluid (60 ml) in a 6-hour period, or a dynamic flow rate of up to 10 ml per hour. The assembly view of the polyMed pump design is shown in Figure 3. Figure 4 illustrates a schematic view of the SPH pump’s principal of operation. The pump is heated until the hydrogel valve reaches a transition temperature, which causes the hydrogel beads to shrink allowing the aqueous solution to pass through the basket of the valve and wet the SPH polymer, which initiates pump dispensing. The SPH polymer rapidly expands, forcing the sealant out of the polyMed pump in a controlled delivery.

Future Directions

We intend to explore the marketplace for wound care therapy, medical sealant dispensing and surgical applications. Eden Medical is presently developing a larger capacity pump which can dispense at a rate of 10ml per hour for woundcare. Eden Medical is also developing a adhesive sealant dispensing product to prevent skin breakdown.

The pump was tested to evaluate pump stroke, maximum exit pressure, pressure holding time and rise-time characteristics. Figure 7 illustrates the pressure output vs. time for short-duration streaming (i.e. dispensing an antiseptic). The pump test results were impressive, featuring a rapid pressurization time of one second, and maximum pressure of 18.776 psi. A longer-duration pump test is shown in Figure 8. The results were exceptional with a maximum pressure of 18.97 psi, average pump holding pressure of 18.867(130.08 kPa) psi over a 12.0 + hour period.

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