学 位 論 文 の 要 旨

氏名　　吉野　綾

学 位 論 文 名　Applicability of Bacterial Cellulose as an Alternative to Paper Points in Endodontic Treatment

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著 者 名　Aya Yoshino, Mari Tabuchi, Motohiro Uo, Hiroto Tatsumi, Katsumi Hideshima, Seiji Kondo, Joji Sekine

論 文 内 容 の 要 旨

INTRODUCTION

Dental root canal treatment is required when dental caries progress to infection of the dental pulp. A major goal of this treatment is to provide complete decontamination of the dental root canal system. However, the morphology of dental root canal systems is complex, and many human dental roots have inaccessible areas. In addition, dental reinfection is fairly common. In conventional treatment, a cotton pellet and paper point made from plant cellulose is used to dry and sterilize the dental root canal. Such sterilization requires a treatment material with high absorbency to remove any residue, the ability to improve the efficacy of intracanal medication and high biocompatibility. Bacterial cellulose (BC), which is well known as the Asian dessert Nata de Coco, is produced by certain strains of bacteria. The properties and characteristics of BC are substantially different from those of conventional plant cellulose, and BC is distinguished by a high mechanical strength, and absorptive capacity. Furthermore, BC has recently been studied for a variety of biomedical materials. BC has different properties to plant cellulose, even though both exhibit similar properties when used as a traditional treatment material. We therefore hypothesized that BC will serve as a superior dental canal treatment material for intracanal asepsis. The aim of this study is to clarify the applicability of BC as a novel material for dental canal treatment with regard to solution absorption, expansion, tensile strength, drug release, and biocompatibility.

MATERIALS AND METHODS

Specimen preparation BC wet pellicles were produced by static culture of *Acetobacter hanseni*. BC wet pellicles were autoclaved in deionized water, and the process was repeated 3 times. BC sheets were then created with BC wet pellicles frozen and dried using a freeze dryer and pressed into sheets with a thickness of approximately 100 μm using a small press. BC sheets were rolled into a point form. Commercially available paper points (PP) were used as controls. The specific surface area of the sheets was estimated by the nitrogen absorption/desorption method.

Solution absorption and expansion Each specimen was immersed in three solutions overnight for estimation of solution absorption: saline, K^+ free electrolyte fluid, or electrolyte fluid. After overnight immersion, each specimen was weighed to obtain its final mass. The rate of increase of mass in each specimen was calculated as the difference between final and initial mass. The specimens were soaked in the three solutions to estimate expansion due to solution absorption. Specimen thickness was measured under an optical microscope at predetermined times up to 240 min, and specimen expansion was presented as the rate of change of thickness.

Tensile strength The specimen thickness was measured prior to testing with a digital caliper. Specimens were divided into 4 groups, one under a dry condition, and the other three under wet conditions. Wet-condition specimens were soaked in each of the three solutions. Specimens were then subjected to tensile stress on a micro mechanical testing machine. Tensile stress and Young's modulus were estimated.

Drug release One-percent trypan blue solution was prepared as an immersion fluid base. Ultraviolet absorbance (UV) was measured for each dilution using a UV spectrophotometer, and trypan blue concentration was determined by using the standard curve of concentration versus UV absorbance.

Biocompatibility Specimens were implanted in the subcutaneous layer on the back, into the latissimus dorsi muscle, and under the periosteum of the mandibular angle of rats to estimate biocompatibility. Rats were sacrificed by overdosing with anesthetic at 3, 7, 28, and 56 days after implantation. Specimens were explanted with the surrounding tissue, and samples were processed for routine paraffin embedding. Routine hematoxylin and eosin staining was then performed.

RESULTS AND DISCUSSION

Characterization of specimens BC had a unique laminated structure consisting of compact layers and porous interconnecting layers resembling a *mille-feuille* in scanning electron microscope image. BC had a larger specific surface area (49 m^2/g) than that of PP (1 m^2/g).

Solution absorption and expansion BC showed noticeably higher absorption than PP.

The absorption rate of BC was 85-fold its weight, while that of PP was about 8-fold its own weight. Therefore, BC is capable of effectively removing dental root canal fluid. BC showed significantly higher expansion than PP. BC expanded to about 3 times its initial thickness after 4 h, whereas PP showed no obvious expansion in thickness during the soaking period. Recently, calcium hydroxide paste and antibiotics have been widely used in intracanal medication, but their efficacy depends on concentration and duration of contact. A more detailed investigation is needed to elucidate the effect of pressing medicaments onto dental canal walls.

Tensile strength PP showed significantly higher tensile strength than that of BC under the dry conditions. However, PP was drastically weakened under the wet conditions, while the tensile strength of BC showed no significant change under either condition. Thus, the tensile strength of BC was higher than PP under wet conditions. This means that BC maintains tensile strength after absorption of root canal fluid or blood, and the inserted BC can be easily removed without fragmenting.

Drug release The cumulative release of trypan blue was significantly greater from BC than from PP. The average levels of trypan blue released from BC were around 20-fold larger than those from PP at 3 min. Therefore, BC can retain a large amount of liquid medicaments which might improve efficacy.

Biocompatibility In the animal experiments, histological examination showed that BC had not been resorbed under the periosteum of the mandibular angle. On day 3, BC was surrounded by inflammatory cells, and no cell invasion was seen, whereas PP seemed to fragment, and inflammatory cells had infiltrated the spaces between the PP fragments. Eight weeks later, a higher number of giant cells were observed for PP than for BC. BC maintained its physical integrity in all groups and did not fragment, and foreign body reaction was seen only in the area surrounding BC. BC in the subcutaneous layer and in the latissimus dorsi muscle showed similar results. The present findings indicate that BC is safer for use in biological tissues than more widely used filling materials. However, further clinical examinations that include application to the dental root are needed.

CONCLUSION

A novel material for dental canal treatment made from BC has favorable material and biological characteristics compared with conventional PP. The absorption rate of BC was 10-fold greater than that of PP, providing a significantly higher expansion of BC over PP. The tensile strength of BC was higher than that of PP under wet conditions. The animal experiments showed that BC maintains its physical integrity and does not fragment, and only a small foreign-body reaction was observed. This is the first study to demonstrate that BC has good potential for use as a material for dental root canal treatment.