Immunomodulatory Microneedle Patch for Periodontal Tissue Regeneration

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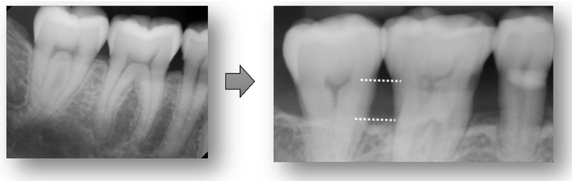
INTRODUCTION

Periodontitis is a **prevalent** chronic **destructive inflammatory** disease affecting tooth-supporting tissues in humans. CDC reports that 47% of adults over the age of 30 years have some form of periodontal disease and one in five seniors have lost all their teeth.

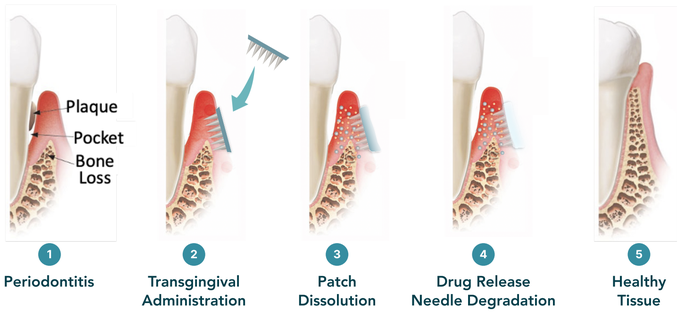


*Images from UCLA dental clinic

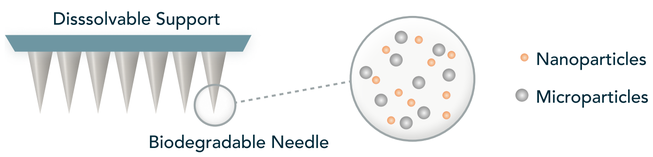
The inflammation is caused by an increasing population of pathogenic bacteria. As the host immune cells fights bacteria, they also deteriorate the gums, bones, and other tissues that support the teeth.

MATERIALS & METHODS

Drug delivery in the oral cavity is challenging due to bacterial infection, saliva secretion and poor local retention. To address this challenge and achieve local and sustained drug delivery, we have developed a biodegradable microneedle (MN) patch that can be inserted into the pocket between the tooth and gingival tissue for a painless and suture-free placement into the gingival tissue.

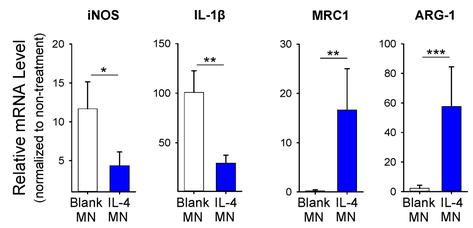


Here we design a modular MN patch for a multiplex delivery: (1) the base membrane of the MN patch is dissolvable for a burst release of antibiotics, (2) biodegradable nanoparticles (NPs) in MNs offers a sustained delivery of antibiotics, and (3) heparin-coated mesoporous silica microparticles (SiMPs) are used as carriers to maintain protein stability and ensure a prolonged delivery of IL-4 and TGF-β.

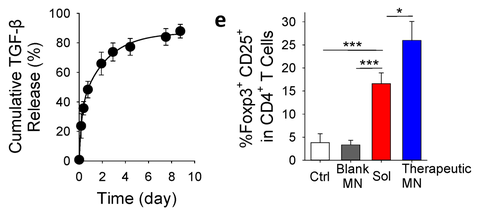


RESULTS - IN VITRO

For macrophage: sustained release of IL-4 from MN patches over time significantly suppressed the expression of pro-inflammatory genes such as iNOS and IL-1β while inducing anti-inflammatory genes such as MRC1 and ARG-1.

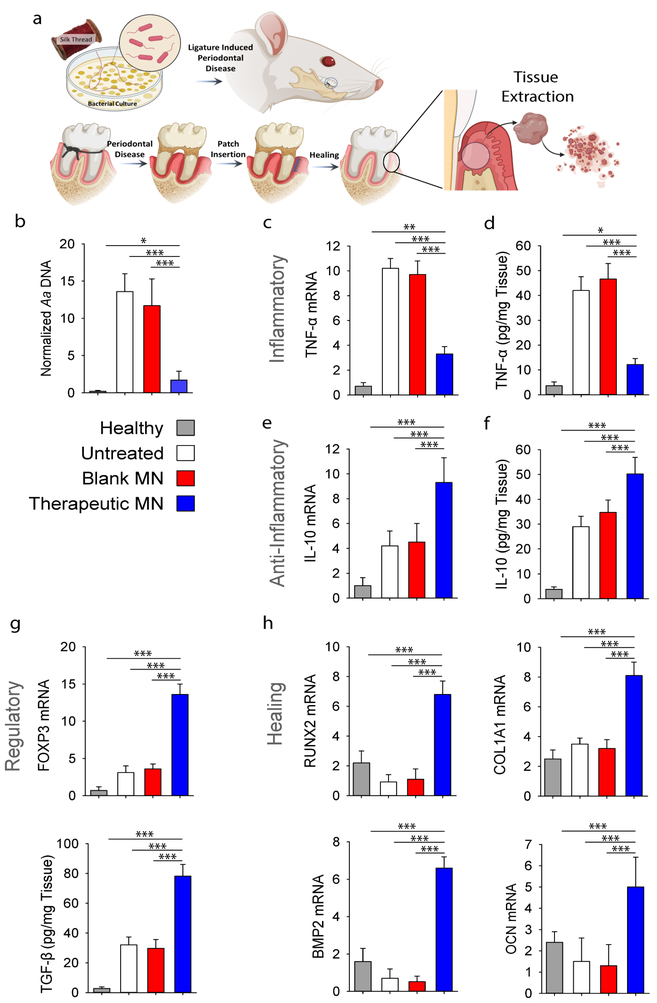


For T cells: Sustained release of IL-4 and TGF- significantly induced Treg formation, which was more effective than adding the soluble form of IL-4 and TGF-β in culture media.



RESULTS - IN VIVO

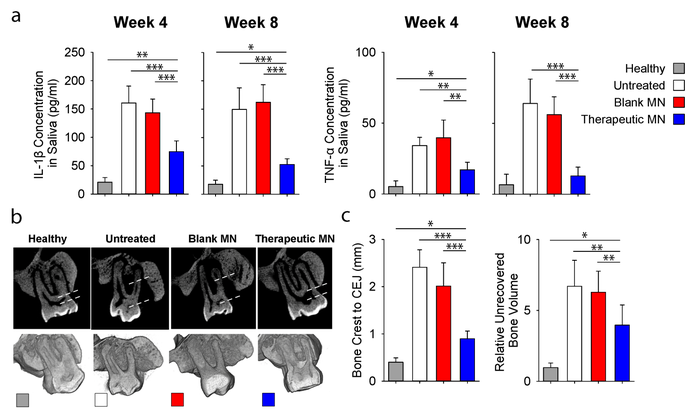
The functionality of the designed MN patch was tested in vivo by using a rat model of periodontitis.



RESULTS - IN VIVO CONT.

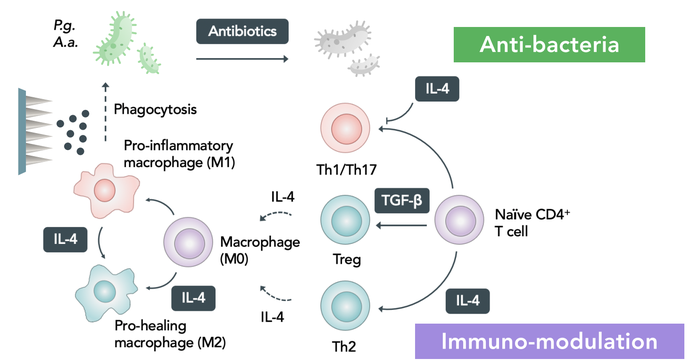
Therapeutic patches effectively inhibited the bacterial growth, significantly reduced the level of pro-inflammatory cytokines, increased the expression of anti-inflammatory cytokines and successfully induced pro-healing genes

Eight weeks post-insertion, the bone regeneration at the defect site was assessed by using microcomputed tomography (microCT).



CONCLUSIONS

We developed a modular MN patch that delivered both antibiotic and cytokines into the local gingival tissue to achieve immunomodulation and tissue regeneration.



ACKNOLEDGEMENT

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