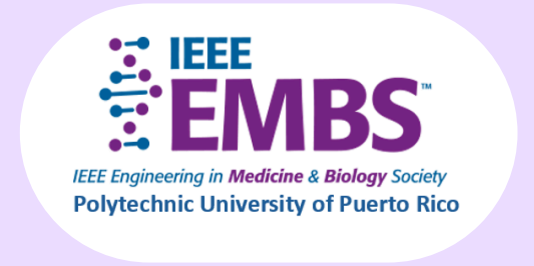


Evolution and Use of Bone Adhesives Based on TCP/HA Configurations with Phosphoserine and TTCP for Treating Rib Fractures

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ABSTRACT

This review serves as a theoretical comparative analysis of calcium phosphate-based bone adhesives, specifically two adhesives Tetranite (TTCP/phosphoserine) and OsStic™ (TCP/HA with catechol functional groups). The methodology focused on a literature review using PubMed, ScienceDirect, Scopus, and Google Scholar, evaluating their adhesion mechanisms, mechanical properties, biocompatibility, and performance in physiological environments. Both adhesives stand out for osteoconductivity and adhesion in physiological conditions, but their application in rib fractures remains challenging due to respiratory cycle motion. This work proposes a theoretical modification of OsStic™ by incorporating collagen hydrogels to introduce reversible flexibility without affecting structural strength or osteoconductivity.

INTRODUCTION

The respiratory cycle hinders the stability of bone fragments with traditional methods such as plates and screws. Bone bioadhesives have created a window as an alternative, offering the necessary osteoconductivity and adhesion, as well as the possibility of injectable application. Tetranite (TTCP/phosphoserine) and OsStic™ (TCP/HA with catechol functional groups) show promising mechanical properties, but their application in ribs requires improvements in flexibility. The incorporation of collagen hydrogels could allow a more adaptable adhesive to physiological movement, maintaining structural strength and biocompatibility while creating permissible degrees of flexibility.

OBJECTIVES

- Investigate the feasibility of applying bone adhesives for the treatment of rib fractures.

METHODOLOGY

Phase 1: Identification and Selection of Bone Bioadhesives

- Review of titles and abstracts.
- Selected: Tetranite and OsStic™
- Criteria: adhesion in wet environments, biocompatibility, and osteoconductivity

Phase 2: Comparative Analysis of Properties and Biomechanical Limitations

- Understanding of chemical composition, adhesion mechanisms, mechanical strength, setting times, as well as chemical behavior under potential alterations.
- Comparative evaluation of Tetranite and OsStic™ regarding adhesion performance, mechanical resistance, and behavior in wet and physiological environments.
- Limitation: movement in rib fractures due to the respiratory cycle, requiring modifications to their structure.

Phase 3: Identification and Evaluation of Hydrogels as Modification Agents

- Evaluation of their capacity to retain water, allow reversible deformations, and tolerate physiological movement.
- Hydrogels studied: alginate and polymers commonly used in bone applications.

Phase 4: Selection of Collagen Hydrogel

- Chosen based on its biocompatibility, chemical affinity with TCP/HA, and ability to form a hydrated network as a mechanical buffer.
- Benefits: reversible flexibility allowing controlled deformation.

Phase 5: Comparative Theoretical Application

- Use of all collected information to formulate a chemical modification proposal.
- Objective: improve dynamic performance for application in rib fractures.

ANALYSIS AND RESULTS

OsStic™ showed higher adhesive strength in wet environments, in addition to its biocompatibility and osteoconductive capacity, making it more suitable for rib fractures where stability under physiological microstrains is required. Hydrogels were evaluated as modification agents; collagen hydrogel was selected for its chemical affinity with TCP/HA and its ability to form a hydrated network that acts as a mechanical buffer. The theoretical incorporation of collagen into OsStic™ would allow a flexible adhesive, capable of tolerating the microstrains of the respiratory cycle without losing structural strength, making its future application in experimental studies feasible.

CONCLUSION

Calcium phosphate based bone bioadhesives presented: Tetranite and OsStic™ show potential for fracture stabilization. The different capabilities described, together with hydrogels such as collagen, could add the elastic property necessary for the environment of interest, although these hydrogels have already been studied with other adhesives, their integration into calcium phosphate-based systems represents a promising extension of their use as a biomaterial whose properties would theoretically allow resistance to microstrains, thus directing their use toward rib fractures. The lack of experimental studies limits certainty only to written formulation; however, future in vitro and in vivo studies would confirm or deny the viability of the proposed theoretical modification with the search for matrices with organic and inorganic duality.

FUTURE WORK

- Translate theoretical findings into experimental work.
- Use the compiled data to perform practical experiments to validate the theoretical proposal.

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Data

Adhesive	Properties	Value
OsStic™	Maximum pull-out force (initial, in vivo)	6.09 N
	Minimum pull-out force (in vivo, after day 7)	3.09 N
	Pull-out force (after day 28, recovery, biologically integrated)	6.37 N
	Pull-out force ex vivo vs fibrin	~7.64 N vs ~0.21 N
Tetranite	Adhesion to cortical bone (TTCP/OPLS as reference)	2 Mpa
	Shear adhesion	6.6–7.3 MPa
	Adhesion to cortical bone (TTCP/OPS nPDA modified)	1.0–1.6 MPa
	Initial adhesion (TTCP/OPS nPDA) in bone	0.5–0.6 MPa