Potential of Barnacle Cement in Dentistry

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Abstract

The barnacle adheres tenaciously to underwater substrata by secreting cement. Lauded for its mechanical properties and water insolubility, barnacle cement was explored in this study for its potential in dental application. Its biocompatibility, speed of polymerisation, aesthetic appeal and acid-resistance was investigated. To study acid-resistance, teeth coated with barnacle cement were immersed in Coke and visual alterations were observed. The effect of Ca^{2+} ions and electromagnetic radiations on cement polymerisation time was studied. Biocompatibility of barnacle cement was determined through toxicity assays with the flat worm *Caenorhabditis elegans*. Barnacle cement did not induce death of *C. elegans*. It was also of similar color to teeth, making it aesthetically appealing. Rate of barnacle cement polymerisation, however, was found to be slower than synthetic adhesives, and the cement was not resistant to acids. Thus, at present, the applicability of barnacle cement as a dental adhesive is limited. With further research on enhancing acid-tolerance and polymerisation rate, effective barnacle cement based dental adhesives may be possible.

Introduction

Today, dental sealants are placed on pits and fissures of teeth to provide a physical barrier against cariogenic bacteria. However, harsh oral conditions obstruct adhesion and reduce effectiveness of current sealants in treating caries [1]. In vivo studies have also shown that certain dental adhesives (Admira Bond, Gluma Comfort Bond) have cytotoxic effects [2]. Ideally, dental adhesives must bond permanently, be biocompatible, of high colour stability, can be handled conveniently by dentists [1] and insensitive to water contamination [3]. One possible adhesive is the barnacle cement. Barnacle cement is 90% protein, naturally occurring and is able to resist both enzymatic and chemical degradation at room temperature [4]. The cement is able to rapidly polymerise and adhere to a variety of substrates, and is insoluble once polymerised. When placed on a wet surface, barnacle cement was favored over other commercial dental adhesives such as zinc phosphate cement [5]. Past researches advocated the potential of barnacle cement in dentistry solely based on its mechanical properties and biochemical composition. Yet, other properties vital in dentistry such as acid resistance, biocompatibility, speed of polymerisation and aesthetic appeal have not been studied in context. Therefore, our study aims to investigate these properties of barnacle cement and determine its applicability as an alternative dental adhesive and sealant.

Hypothesis of the study

Amphibalanus amphitrite barnacle cement possesses the necessary properties to act as a dental adhesive and sealant.

Objectives of the study

To determine the applicability of barnacle cement as an effective and novel alternative dental adhesive by testing its biocompatibility and acid resistance, as well as determining its polymerisation rate and aesthetic appeal.

Methods and Materials

I) Preparation of Barnacle Cement - *Dyeing and Extraction of Barnacle Cement*

I. Collection of barnacles at fouling raft

II. Immersion of barnacles overnight in food colouring solution

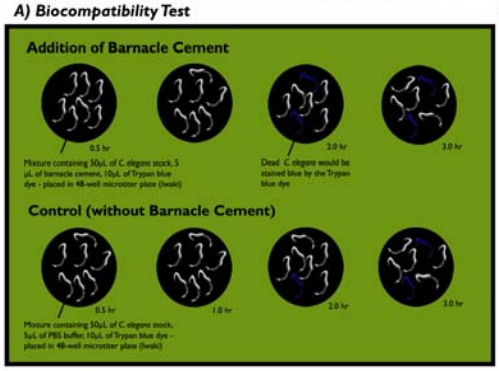
III. Barnacles were then dried and sat in air for about 2hrs

IV. A dissecting needle was used to pick gently at the periphery of the base plate

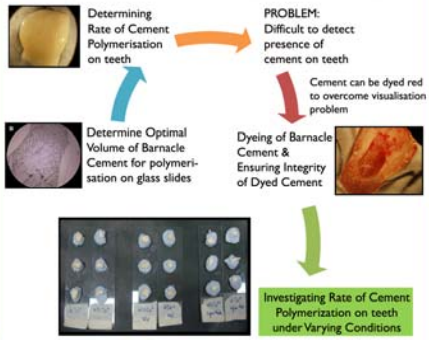
V. 1-2μL of barnacle cement was then extracted using a micropipette

II) Evaluation of Barnacle Cement in Dental Applications

A) Biocompatibility Test



B/C) Morphological & Rate of Polymerisation Analysis



D) Acid Resistance Test

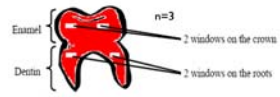


Diagram of demarcated tooth

1. Windows on the crown and root (one each) were coated with barnacle cement. The other windows were coated with acid-resistant nail varnish to function as a positive control.

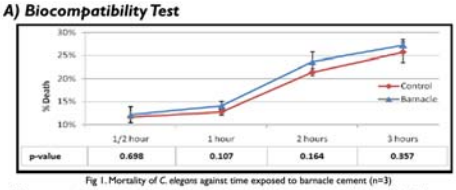
2. Tooth samples were then immersed in Coke for 72 hrs

3. Coke was changed at 24hr-intervals with pH measured

4. Images were taken using the stereomicroscope for comparison

Results

A) Biocompatibility Test



p-value	1/2 hour	1 hour	2 hours	3 hours
	0.698	0.107	0.164	0.357

Fig 1. Mortality of *C. elegans* against time exposed to barnacle cement (n=3)

Biocompatibility test: barnacle cement did not cause death of *C. elegans*

B) Morphological Analysis - Aesthetic Appeal

Fig 2. Barnacle cement on tooth surface (n=3)

Barnacle cement cannot be easily observed - good aesthetic appearance

C) Rate of Polymerization Test

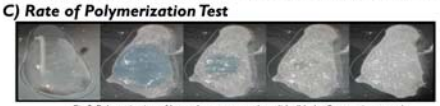


Fig 3. Polymerization of barnacle cement on glass slide (Under Stereomicroscope)

Appearance of the hardened cement indicates end of polymerization

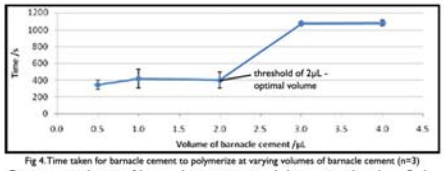


Fig 4. Time taken for barnacle cement to polymerize at varying volumes of barnacle cement (n=3)

Optimum volume of barnacle cement used determined to be ~2μL

Ensuring Integrity of Dyed Barnacle Cement

		1	2	3	4	Avg
Dyed	Start /s	52	45	47	38	45.5
	Stop /s	275	290	309	303	294.25
Undyed	Start /s	54	53	55	51	53.25
	Stop /s	288	302	254	283	281.75

p-value = 0.723 (difference is insignificant; integrity is ensured)

Fig 5. Comparison of time taken for dyed & undyed barnacle cement to polymerise (n=4)

Ensuring Integrity: Difference in polymerisation time was insignificant

Results (continued)

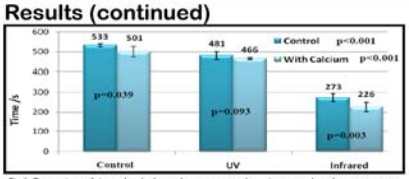


Fig 6. Comparison of time taken by barnacle cement to polymerise on teeth under exposure to calcium, UV light and Infrared radiation (n=4)

D) Acid Resistance Test

On Crown Surfaces

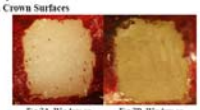


Fig 7A. Window on enamel coated with Barnacle Cement

Fig 7B. Window on enamel immersed in Coke (pH 3.3) for 72

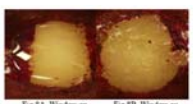


Fig 8A. Window on enamel coated with transparent, acid-resistant nail varnish

Fig 8B. Window on enamel immersed in Coke (pH 3.3) for 72 hrs

On Root Surfaces

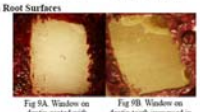


Fig 9A. Window on dentin coated with Barnacle Cement

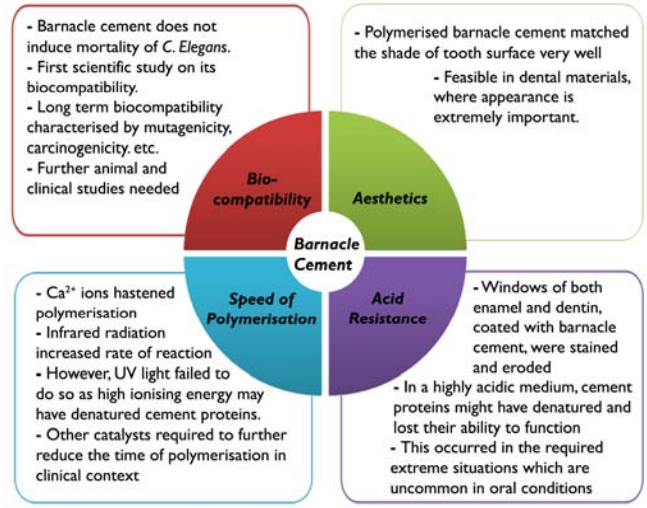
Fig 9B. Window on dentin tooth immersed in Coke (pH 3.3) for 72 hrs

Fig 10A. Window on dentin coated with transparent, acid-resistant nail varnish

Fig 10B. Window on dentin immersed in Coke (pH 3.3) for 72 hrs

Layer of barnacle cement offered little protection to teeth immersed in Coke. Teeth that were coated with acid-resistant nail varnish remained constant (positive control for comparison).

Discussion/Conclusion



Future Work

Carry out human cell culture tests to validate the bio-compatibility	Investigate the adhesion strength of cement to tooth surfaces in vitro	Assess the effect of barnacle cement on re-mineralisation of enamel and dentin

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*All photographs are self-taken