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Study of Using Alginate Material as an Alternative Method for Foot Orthoses Casting

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ABSTRACT

Background: Orthosis molding utilizes *POP Bandages*, *Foam Impression Box (FIB),* and *3D foot scanning* media. Printing with *FI* B produces accurate prints, consistent sizes, and fast procedures. The availability of *FIB* in Indonesia is still difficult due to imported goods. *Alginate material* dental molding material in the form of powder. Objective: To determine whether the *Alginate Material* specimen can be used as a *Foot Orthosis* molding medium referring to the *gold standard* based on the size difference of the *positive cast*, the surface condition of the *negative cast*, and the 3 contact areas on the *positive cast*. Methods: Experimental, 1 participant with normal arch, comparing the dimensions of size, shape of *positive cast* and *negative cast* and 3 contact areas using univariate and bivariate tests. Results: Specimen 1 and specimen 2 have a p value ≥ 0.05, which means that the size results of specimens 1 and 2 are not significantly different from the *gold standard*. The observation results of *positive cast* specimens 1 and 2 have results that are close to the *gold standard*. Conclusion: *Alginate material* specimens can be used as a medium for molding *Foot Orthosis*. Suggestion: Can expand the scope of research on the feet of participants who have deformities and add variables to be measured in order to get more detailed and specific results.

INTRODUCTION

Based on epidemiological data, 90% of the prevalence of pain complaints is found in foot pain or foot pain (Martinez-Calderon et al., 2018). The causes of someone complaining of pain in the feet vary including *plantarfasciitis*, *pes planus*, *pes cavus*, *hallux valgus*, *rheumatoid arthritis,* diabetes mellitus and other structural diseases. In terms of prosthetic orthotics, the above cases can be given motion aids in the form of foot orthoses with specific designs according to the doctor's prescription (Hill et al., 2008). *Foot Orthosis* is a device that is applied to the sole area of the foot with a design that can provide protection, correction or accommodation to the structure of the foot (Evans et al., 2022).

The use of *foot orthoses* has been shown to be effective in reducing pain and improving foot function, including the use of *custom made total contact insoles* and special diabetic shoes (Štajer et al., 2011). There are several types of foot orthoses, including *prefabricated* insole, custom made *simple insole, custom made total contact insole*, *UCBL*, *metatarsal pad* and *heel pad*. Each type of foot orthosis goes through a different manufacturing process. In orthotics, there are 3 methods of molding foot orthoses including the *Plaster of Paris (POP) bandages method*, the *foam impression block method,* and the *3D scanning plantar surface printing* method (Štajer et al., 2011). *Foam impression*, a method of molding a foot orthosis with *foam* media. *Foam impression* is designed to accept pressure and easily follow the shape of the surface of the *impression* object. It is another method of molding the foot other than *POP bandages*, by applying steady and slow pressure downward from the heel area to the fingertips on the *foam* to get accurate, practical and easy-to-control press results. Although *foam impression* is relatively new in Indonesia compared to *POP bandages* that have been used for decades, *foam impression* is superior in speed to be able to print 30 times per hour. The final result of *foam impression* printing is cleaner and tidier for both the patient and the orthotist (Ki et al., 2008). Alginate is the most widely used hydrocolloid molding material in dentistry. This printing material has advantages including easy manipulation, comfortable for patients, more economical prices and does not require a lot of equipment when printing (Dilip et al., 2023). The use of *Foam Impression is* more expensive than *PoP Bandages*. Therefore, researchers want to experiment with *Alginate* material to find out whether Alginate can be used for foot orthosis molding and can be used as an alternative media to

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replace *Foam Impression.* Based on the above background, researchers conducted research with the title "Study of the Use of *Alginate* Material as an alternative to *foot orthosis* molding media".

METHOD

This research was conducted using an experimental method with a descriptive approach. This study aims to determine whether *Alginate* material can be used as a medium for printing *Foot Orthosis* by considering the measured variables. This research was conducted by collecting data using materials that are available and easily obtained in Indonesia, namely *Alginate* material.

The results of this study will be presented descriptively, namely describing *Alginate* materials that are given different treatments and compared with the control. In this study, the performance of each *Alginate* material specimen will be seen when used in addition to dental printing purposes, namely as a medium for printing *Foot Orthosis*. Printing using Alginate Material must be done repeatedly to get a variety of printing results so that in data processing more accurate results will be obtained and reduce the element of chance in an experiment, of the printing methods commonly used in the field of orthotics such as *POP Bandages* and *Foam Impression Box*, the researchers used only *Foam Impression Box which was printed* once as a comparison of Alginate material. Materials Researchers give treatment to Alginate materials from the amount of water given to Alginate materials. The amount of water given will be divided into 2 specimens, namely Specimen 1 where the dose of water and Alginate material is 1: 1 (130gram alginate: 200ml water). And Specimen 2 where the dose of water and Alginate material is 1:2 (130gram alginate: 200ml water).

RESULT

Table 1 shows the average and standard deviation of the *metatarsal head* diameter, *heel* diameter, foot length of specimens 1 and 2. The average and standard deviation are generated from a total of 4 foot molding trials.

Table 1. Mean and Standard Deviation of Both Specimens and Gold Standard

	***Metatarsal head* diameter (cm)**	***Heel* diameter (cm)**	**Leg length (cm)**
Gold Standard	9,2	5,8	23,8
Specimen 1	(9,15) ± (0,058)	(5,7) ± (0,125)	(23,8) ± (0,141)
Specimen 2	(9,15) ± (0,058)	(5,8) ± (0,095)	(23,5) ± (0,500)

The average *metatarsal head* diameter of specimens 1 and 2 has the same average of (91.5) with a standard deviation of (0.058). The largest average *heel* diameter is specimen 2 (5.8) with a standard deviation (0.095) and the smallest average *heel* diameter is specimen 1 (5.7) with a standard deviation (0.125). The largest average leg length is specimen 1 (23.8) with a standard deviation (0.141) and the smallest average leg length is specimen 2 (23.5) with a standard deviation (0.500).

Table 2. Specimen p value results based Gold Standard

	Gold Standard (cm)	**Specimen 1 (cm)**	**P value**
Diameter of metatarsal head	9,2	(9,15) ± (0,058)	0,125
Heel diameter	5,8	(5,7) ± (0,125)	1,000
Foot Length	23,8	(23,8) ± (0,141)	0,540
	Gold Standard (cm)	**Specimen 2 (cm)**	**P value**
Diameter of metatarsal head	9,2	(9,15) ± (0,058)	0,540
Heel diameter	5,8	(5,8) ± (0,095)	0,540
Foot Lenght	23,8	(23,5) ± (0,500)	1,000

After testing the size of the *Gold Standard* from Table 2 there is a p value ≥ 0.05 in all measurements of *metatarsal head* diameter, *heel* diameter, foot lenght in specimens 1 and 2. This shows that each size in specimen 1 and specimen 2 does not have a significant size difference during the 4 trials.

Table 3. Result of 3 Contact Areas on Positive Cast of Each Speciment

Positive Cast Speciment	Metatarsal Head 1	Metatarsal Head 2	Heel
1.1	✓	✓	✓
1.2	✓	✓	✓
1.3	✓	✓	✓
1.4	✓	✓	✓
2.1	✓	✓	✓
2.2	✓	✓	✓
2.3	✓	✓	✓
2.4	✓	✓	✓

*(✓) = Touching the Surface
*(-) = Not Touching the Surface

Table 3 shows the condition of the *positive cast* when placed on a flat surface. Specimens 1 and 2 produce *positive casts* with neutral foot conditions where the 3 contact areas can touch the flat surface with a neutral heel position.

DISCUSSION

Alginate material is an elastic *irreversible hydrocolloid molding* material used to make denture molds, primary pre-elimination molds for full dentures, *orthodontic molds* and study model molds (O'Brien, 2002). In the field of dentistry, *Alginate* is an *irreversible*, *hydrocolloid* molding material that is elastic. Various papers have been published on alginate materials both regarding their composition, indications for use and failure factors. Foot molding using alginate material requires more preparation before molding. This is due to the different form and application compared to gold standard. Of the two test specimens in the preparation spe issued by the researcher for mixing water and alginate material before printing should be more attention, mixing water into alginate material is done little by little until the mixture is thick enough. The recommended powder to water ratio mixing method is usually 1:1 (Dilip et al. 2023). The stirring technique is done slowly when mixing the powder with water slowly, if the mixing is done directly, it will make the mixture become bubbly and clumpy so that the mixture cannot be stirred evenly.

Dimension size of positive cast

Positive cast measurement dimensions included metatarsal head diameter, heel diameter, and foot length. These dimensions were measured on all positive casts and 1 gold standard using a caliper. The measurement results were entered into a statistical data processing application, in the above test, a p value ≥0.05 indicates an insignificant difference in molding size. This indicates that the molding done with the test specimen is good because there is a large enough measurement range. If the p value ≤0.05 indicates a significant difference in molding size. This indicates the molding done with the test specimen is not good because there is a large enough measurement range. In both specimens, there is an insignificant difference in reference to the *gold standard*. This shows that there is little difference in molding using specimens 1 and 2 of the 4 experiments conducted. So, from this research, the size of specimens 1 and 2 has more accurate results referring to the *gold standard.*

3 Contact Area

There are 3 areas that become a reference for a cast to be said to be in a normal or neutral position, namely the first metatarsal ball, the fifth metatarsal ball and also the heel at the same time touching the surface of the base so that the expected neutral heel position (Telfer et al, 2012). Positive cast gold standard can achieve 3 contact areas, namely the 1st metatarsal, 5th metatarsal and heel area that can touch the

surface of the base simultaneously with a neutral heel position (not leaning to the right or left). both specimens there are 4 times the experiment, obtained the 4th *positive cast* mold results from specimens 1 and 2 can achieve 3 contact areas where the cast position is stable and metatarsals 1 and 5 can touch the surface of the base with the heel in a neutral state.

CONCLUSION

Alginate can be used as a *Foot Orthosis* molding medium based on the size of the *positive cast*, the shape of the *negative cast* and also the 3 contact areas. *Positive cast* printing using *Alginate* specimens 1 and 2 have size results that are close to the *positive cast gold standard* results (p - ≥ 0.05). *Alginate* can serve as one of the foot printing media in the field of prosthetic orthotics. Alginate material shows results that are close to the gold standard which can be used as one of the printing media in the field of prosthetic orthotics.

From the 2 specimens that have been tested and studied based on the variables described above, future researchers can expand the scope of research on the feet of participants who have deformities and add variables to be measured in order to get more detailed and specific results.

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