

# ANALYTIC STUDY OF THE INFLUENCE OF IMPRESSION MATERIALS AND TECHNIQUES ON THE ACCURACY OF LOST WAX TECHNIQUE IN DENTISTRY – USING THE ISHIKAWA DIAGRAM

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**Summary:** Introduction: Lost wax technique in dentistry consists of multiple clinical and laboratory steps. Every step can be influenced by many factors which can have negative impact on the accuracy of the final dental restoration. After preparation of the teeth, impression taking is a first step in fabrication of fixed partial dentures in prosthetics. There are many conditions that can affect the accuracy of the dental impression.

Ishikawa diagram, also called Cause-and-Effect Diagram is a tool of quality for detecting causes that influence appearing of the problem. It is a scientific tool which graphically presents relation between consequence and all factors that could cause it and helps to identify, sort and present possible causes of the problem on the more visual, easier and systematic way. Ishikawa diagram is useful in quality defect prevention.

The aim of this study was to analyze factors influencing accuracy of dental impression using Ishikawa diagram.

**Materials and method:** Ishikawa diagram consists of several steps: defining problem- clearly defining the consequences of problems and errors; the selection of the basic structure- draw a diagram using appropriate groups of causes- material, method, human factor and environment; elaboration of the diagram; branching process-more detail representation; analyze of the diagram- analyzing all causes, determining the level of their impact and proposing corrective measures and schedule for their removal.

**Results:** Using the specific Ishikawa diagram, with four primary branches- material, method, human factor and environment, it can be found that chemical composition, physical and mechanical properties of the impression materials could influence the accuracy of the dental impression. The elastomeric dental impression materials are polysulfides, polyethers, vinyl polysiloxanes (addition cure silicones) and condensation cure silicones. Polyethers and vinyl polysiloxanes have the best detail reproduction ability, and they are the most commonly used materials for impression taking. There are significant differences in detail reproduction, dimensional stability, wettability and viscosity between impression materials. Method, selection of a technique and a tray used for impression taking, influence the accuracy of the impressions. There are a few impression taking techniques such as mono-phase, one-step, two-step, putty light body technique. Tray can be custom or individual tray, metal or plastic tray, dual-arch or complete arch. In the mouth there are specific conditions, like variable temperature, variable humidity, constant presence of saliva, specific characteristics of the object that is coping. Environmental room factors, storage time, setting time, working time with impression material, using or not the impression disinfectants and the time and conditions until gypsum casting have a significant influence on impression accuracy. Human factor is a relevant factor because skill abilities, experience and knowledge of the operator influence all the factors. Depending on conditions, the proper selection of impression material and technique is crucial to reduce the error of the final impression to a minimum.

**Conclusion:** Analyzing the Ishikawa diagram, through the systematic graphic review, operators can be educated to choose working protocol that leads to the fabrication of an accurate indirect dental restoration.

**Keywords:** fixed partial denture, dental impression, accuracy, Ishikawa diagram

## INTRODUCTION

Lost wax technique is the way to produce wax replica in cast metal. It is the method for detailed reproduction of an irregular shape model, like fixed partial dentures. To produce an indirect dental restoration, it is necessary to take many clinical and laboratory steps. Since there are many steps in this process, every step can impact the accuracy of the final dental restoration. First step of this procedure is impression taking of the prepared teeth. There are many factors which can influence the accuracy of the impression and consequently on the accuracy of final dental restoration. Many authors recognized the importance of continuous effort for improving the accuracy of dental restorations [1, 2, 3].

Elastomers are materials of choice for impression taking during the fabrication of fixed partial denture. Knowledge of material properties and methods of its use is very important requirement to obtain an accurate dental impression. One of the methods to identify properties of quality of an impression and to show cause-consequential relations that leads to inaccurate dental impression is the Ishikawa diagram.

Ishikawa diagram, also called Cause-and-Effect Diagram is a tool of quality for detecting causes that influence appearing of the problem. It is a scientific tool which graphically presents relation between consequence and all factors that could cause it and helps to identify, sort and present possible causes of the problem on the more visual, easier and systematic way [4]. Ishikawa diagram is useful in quality defect prevention [5].

The aim of this study was to analyze factors influencing accuracy of dental impression using the Ishikawa diagram.

## MATERIALS AND METHOD

Ishikawa diagram also called Cause-and-Effect Diagram has been chosen as a method for determination of properties and characteristics of quality.

After defining problem, the brainstorming method is applied. Team brainstorming is a tool for provocation and expression of as many causes as possible which may lead to consequences that are being explored.

Analysis of available literature was also used and more relevant factors were found that affect the accuracy of dental impressions.

Than the basic structure of the diagram is chosen:

- drawing a diagram using appropriate groups of causes- material, method, human factor and environment/oral cavity.

- elaboration of the diagram, branching process- more detail representation is done.

- analyzing of the diagram- analyzing the all causes and determining the level of their impact

- proposing corrective measures and schedule for their removal are also undertaken.

Method is characterized by the possibility of further changing on the basis of new knowledge and experiences.

## RESULTS

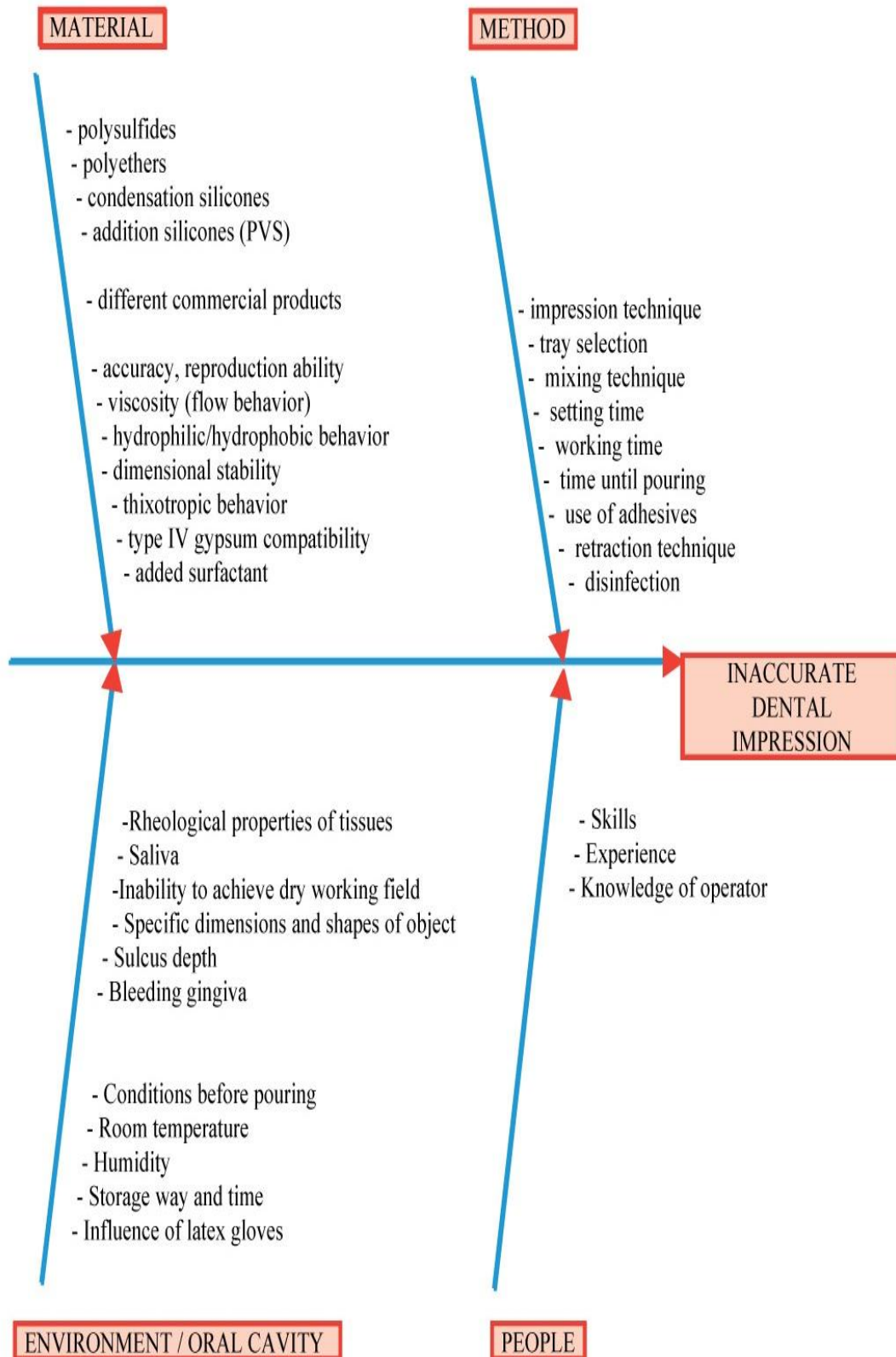
This paper presents practical results in identifying properties and quality characteristics of process in dental impression taking.

We construct specific Ishikawa diagram, with four primary branches- material, method, human factor, environment. The diagram presents, in graphic form, main branches of the causes and their detailed elaboration.

On the main highway of the diagram, is an inaccurate dental impression, as a consequence which may be caused by any of the written causes (Figure 1).

### Material

It can be found that chemical composition, physical and mechanical properties of the impression materials could influence the accuracy of the dental impression. There are four main groups of elastomeric impression materials: polysulfides, polyethers, condensation-cure silicones and addition-cure silicones. Knowledge of material properties is crucial for the exploitation of its positive features, so as to reduce errors to a minimum. The precise reproduction of small features in the order of 20µm or less [6] from the impression and gypsum cast to the final product is essential for the quality of the processed dental implant, inlay, onlay, crown, or fixed partial denture [7]. Surface detail reproduction has been improved with the evolution from reversible hydrocolloids to polysulfide, than condensation silicone and finally, to polyether and vinyl polysiloxane materials [8]. Polyether and hydrophilic addition silicone produce casts with more accurate detail reproduction than low viscosity polysulfide [9]. This disparity is difficult to explain because the wettability of the material is similar.



*Figure 1. Ishikawa diagram presenting causes of inaccurate dental impression*

The difference could be explained by one or more of the following: shear thinning effects, amount and size of filler particles, extent of initial cross-linking, and compatibility of gypsum and impression material [9].

Accuracy depends in a first step on the ability of the unset material to flow around the soft and hard tissues of the mouth. This is necessary for a good contact between the impression material and the tooth. Just after application of the paste in the mouth two parameters are important:

- the viscosity (flow behavior) of the impression material
- the wettability of the moist tissue in the mouth by impression material [7].

Regarding the wettability it was concluded from the void formation in impressions that hydrophilic impression material will wet moist dental surfaces better.[9] The results among investigators have been variable, but there is agreement in the relative order of increasing hydrophilicity for elastomeric impression materials; silicone is less hydrophilic than polysulfide, which in turn is less hydrophilic than polyether [9].

Polyvinyl siloxanes are wide used to obtain dimensional accurate and stable models of oral structure, in particular in the production of inlays, crowns, and bridges. They show smallest dimensional changes in comparison to other elastomeric impression materials [10].

Viscosity is one of the factors that influence surface detail reproduction. Viscosity of impression materials can be light body, medium/regular body, heavy body or putty. Except the viscosity, which affects the detail reproduction, selection of impression technique with these different materials is also important in achieving accurate impression.

Thixotropy is the property of some fluids that are viscous under normal conditions to flow (become less viscous) over time when shaken, agitated, or otherwise stressed. This is the property which some impression materials, like PVS and polyethers possess. This feature allows usage the same material for tray or syringe, depending on the type of mixing.

Type IV gypsum compatibility depends on wettability characteristics of impression materials. The compatibility is less with hydrophobic materials, such as addition silicones. These materials reproduce detail of the impression surface, but fail to transfer detail to the cast [11]. The incorporation of certain nonionic surfactants into silicone and polysulfide elastomers increases their wettability by gypsum products and consequently results in less bubble entrapment in poured casts [9].

## Method

Continuing effort to improve performance and product quality, by manufacturers, requires improvement in the way of handling with the material, by dentists and laboratory technicians.

Practitioners should be aware of tolerable time delay for which the selected impression material will remain dimensionally accurate [9]. With these materials, the dimensional accuracy is usually time-dependent. In general, polyether and polyvinyl siloxane impression materials remain dimensionally accurate for a prolonged setting period of time (up to one week) [9]. The condensation silicone system should be poured as soon as possible after a period of relaxation of 30 minutes. VPS impression materials demonstrate excellent accuracy, and the fewest dimensional changes after multiple pours [12, 13].

“The manner in which the impression was made may be more important than the material” [9] There are a few impression taking techniques such as mono-phase, one-step, two-step, putty light body technique. There are still conflicting opinions in the professional and scientific literature about which impression taking technique provides the most accurate impression. Some authors found that mono-phase impression technique produce better detail reproduction, and some authors found that dual-phase impression technique produce less voids comparing to mono-phase impression technique [8].

Tray can be custom or individual tray, made of metal or plastic, dual-arch or complete arch. The silicone, polysulfide rubber, and polyether impression materials can record the shape of tissues accurately if they are adequately supported by an accurately fitted tray. Greater accuracy was obtained in custom trays than with impression made in stock trays. The bulk of elastomeric materials and the size of undercut are of major importance. Accuracy and consistency are best maintained by use of custom tray and adhesives to retain polyvinyl siloxanes [9].

Mixing of impression material can be manual and automatic mixing. By using automatic mixing system, good results are obtained with less expenditure of time as well as less discomfort and inconvenience for the patient [14]. Compared to hand mixing, both automatic and electronic techniques enhance the quality of definitive impression. Also, auto-mixing was considered to be more economical than hand mixing, because it wastes one third less volume of material as compared to hand mixing [9].

About the disinfection after impression taking, recommendation has been made that impression materials can be only spray disinfected to avoid imbibitions and dimensional changes. Long term

immersion has been shown to alter the accuracy of both polyether and PVS. Recent studies demonstrate that impression material accuracy was unaffected by immersion disinfection if the recommended time of disinfection is used [9].

#### Environment

Since oral mucosal tissues contain both the major and minor salivary glands, it is very difficult to ensure a dry field when making impression to capture details. When using PVS, moisture control remains a critical factor for the predictable success of the clinical impression. However, polysulfide and polyether impression materials, because of their hydrophilic behavior, should be more compatible with the inherent moisture of the tissues. Even though there is a need to control salivary secretions when making impressions with polysulfide rubber. Polyether produced the best detail reproduction under moist conditions [8, 15].

Temperature differences between oral cavity and the room temperature are significant. Impressions are made at 37° C, and they are stored at room temperature which is about 22 +/- 2° C. Besides, there can be large temperature changes during transfer to a laboratory. All of these changes may affect accuracy of the impression, because of their coefficient of thermal expansion and contraction. There are also dimensional changes in impressions, such as polymerization shrinkage that every polymer has. To compensate these dimensional changes, some authors found that storage of PVS and polyether impressions at 4° C for 24 hours followed by allowing the impression to reach room temperature resulted in slightly expanded impression that partially compensate polymerization shrinkage. They also found that heating of polyether impressions at 40° C for 24 hours and then allowing the impression to reach room temperature also resulted in slightly expanded impression. Reported dimensional changes in this study were in range from 1 to 18 µm [16].

The ability of impression material to record detail on moist surfaces, is related to viscosity and rheological properties of the material. Polyether material, which is the most hydrophilic impression material, and PVS are accurately able to reproduce deep grooves on moist surfaces. The other silicone products are not so reliable for this purpose [17].

The use of gingival retraction materials may affect stability of impression materials. Even in small amounts, they can jeopardize the integrity of impression materials. Once obtained the effect of gingival retraction, the substances should be totally removed with air/water sprays [18].

#### People

Knowledge of the properties and behavior of impression materials, the impact of various factors on their accuracy and dimensional stability is of great importance for achieving the best results in impression making. In the era of computerized dentistry, there is a requirement for increasing skill abilities and knowledge of the operators, in the pursuit of creating the best possible dental restoration. The operators should be aware of all advantages and disadvantages of impression materials, and should know how to use them to take the best of the good properties and to recognize their limits. Experienced and skilled operator, who follows the trends and recommendations for use in the professional or scientific literature is the solution that arises.

#### CONCLUSION

Considering the existence of additive errors during the process of making dental restorations, application of quality management systems will lead to more accurate impression. Therefore it may lead to more accurate starting point for further phases in production of dental restoration.

It is required to define quality features and to train operators to monitor and enforce this quality of impressions.

Analyzing the Ishikawa diagram, through the systematic graphic review, operators can be educated to choose working protocol that leads to the fabrication of an accurate indirect dental restoration.

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#### АНАЛИТИЧКА СТУДИЈА УТИЦАЈА ОТИСНИХ МАТЕРИЈАЛА И ТЕХНИКА НА ПРЕЦИЗНОСТ ИЗРАДЕ ЗУБНЕ НАДОКНАДЕ КОНВЕНЦИОНАЛНОМ МЕТОДОМ – КОРИШЋЕЊЕ ИШИКАВА ДИЈАГРАМА

**Сажетак:** Конвенционална израда зубних надокнада састоји се од више клиничких и лабораторијских фаза. Свака фаза може бити измењена бројним факторима, који могу имати негативан утицај на прецизност готове зубне надокнаде. Након препарације зуба, узимање отиска је прва фаза у изради зубне надокнаде. Постоје многи услови који утичу на фазу отискивања и на прецизност денталног отиска.

Ишикава дијаграм, такође називан и Узрочно-последични дијаграм је алат квалитета за откривање корена узрока који доводи до појаве проблема. То је научни алат који графички приказује везу између одређене негативне појаве и свих фактора

који на њу утичу и помаже да се идентификују, сортирају и прикажу могући узроци на визуелни, лакши и систематичнији начин. Ишукава дијаграм је користан у превенирању дефеката квалитета одређеног производа.

Циљ ове студије био је да се анализирају фактори који утичу на прецизност денталног отиска коришћењем Ишикава дијаграма.

**Кључне речи:** фиксна зубна надокнада, зубни отисак, прецизност, ишикава дијаграм.