Changes In The Magnetic Attraction By Mineral Water In The Magnetic Dental Attachment

An Nissa Kusumadewi, Lisda Damayanti*, Rukiah**, Risdiana****

* *Faculty of Dentistry, Department of Prosthodontics, Universitas Padjadjaran.*
Faculty of Mathematics and Natural Sciences, Department of Chemistry, Universitas Padjadjaran
Faculty of Mathematics and Natural Sciences, Department of Physics, Universitas Padjadjaran

Correspondence: annissa.kusumadewi@unpad.ac.id

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ABSTRACT

Background: *The magnetic dental attachment is an integral component of the overdenture. Dental magnetic attachment will be in the oral cavity and is influenced by the oral environment. Previous study has shown that acid solutions contained in commonly consumed foods or drinks can corrode magnets and reduce magnetic attraction. Consuming mineral water in daily life is a common thing done by Indonesians. The objective of this research is to investigate the impact of mineral water on both the magnetic attraction and the occurrence of corrosion.*

Method: *Mineral water which are sold commercially with different pH of 6.8 and 7.5, were used. Magnetic dental attachments were immersed in both types of mineral water for 7 and 14 days. The magnetic attraction was quantified by employing a materials testing machine and corrosion on the magnetic surface was seen using SEM.*

Result: *After the immersion of magnetic dental attachments in mineral water with a pH level of 6.8 for 7 days and 14 days, magnetic attraction decreased by 5.36% and 21.77%, respectively. While after immersion at a pH level of 7.5 for 7 days and 14 days, magnetic attraction decreased by 9.39% and 22.89%, respectively. SEM examination showed that the surface of the magnetic dental attachment was corroded after being immersed in both types of mineral water and in both groups of immersion times*.

Conclusion: *Immersing the magnetic dental attachment in the mineral water with different pH level decreased the magnetic attraction force as well as corroded the surface of magnetic dental attachment.*

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INTRODUCTION

Magnetic dental attachment is a type of attachment that serves to add retention and stability to the overdenture. This attachment is attached to the overdenture and will be inside the mouth so that it can be affected by the environment of the oral cavity. Previous studies have shown that immersion of magnetic dental attachment in solutions such as 1% lactic acid liquid, 0.1% sodium sulphide, artificial saliva, and 0.9% NaCl lead to dissolution of magnets, corrosion of magnets, and decreased the magnetic attraction force.[1,2] Kusumadewi et al.[3] conducted research on the effect of immersion of magnetic dental attachment in acidic liquids contained in food and beverage, namely pempek vinegar with a pH level of 3.8 and a solution of honey with a pH level of 5.8. The results showed that all magnetic dental attachments experienced surface corrosion and a decrease in magnetic attraction.[3] This shows that the food and beverage consumed can affect magnetic dental attachment.

Consuming mineral water in daily life is a common thing done by Indonesians. Natural mineral water is microbiologically healthy water that originates from the groundwater table or sediment and emerges from springs tapped into one or more natural exit holes or bore holes. The distinctive qualities of natural mineral water are identified by its composition of minerals, trace elements, or other constituents, along with its inherent purity in its original state.[4–7]

Everyone will consume drinking water every day in varying amounts according to their needs. This allows overdentures with magnetic attachments to be in frequent contact with the water they drink daily. Research on the effect of mineral water on magnetic dental attachment has not been found in the literature. Therefore, we conducted a research study that aimed to examine the impact of mineral water on magnetic attraction and corrosion.

RESEARCH METHOD

Four magnetic dental attachments (Magfit DX 600, Aichi Steel, Japan) were utilized in the study, divided into two groups based on immersion time and two groups based on exposure to mineral water. One magnetic attachment was designated as the control specimen and was not subjected to immersion in mineral water. In this study, we used two kinds of mineral water sold commercially with different pH (6.8 and 7.5), as shown in Fig.1. Each attachment was composed of an assembly and a keeper component., the magnetic assembly and the keeper were immersed separately in mineral water for durations of 7 and 14 days. Following the immersion period, both the assembly and the keeper were allowed to dry. Subsequently, the corrosion on the magnetic dental attachment was examined using an electron microscope (SEM; Hitachi SU3500, Japan). The magnetic attraction was measured using a materials testing machine (Llyod LRX Plus, UK).[8,9] Magnetic attraction was measured by clamping the keeper on the lower arm of the testing machine and the assembly on the upper arm [3]. The magnetic attraction was assessed through a tensile test, the magnitude of the force taken was the maximum load value with units of gram force (gf). The test was carried out using a crosshead speed of 50 mm/min.[2,3,10] Measurements were made 5 times on each specimen, then the values were averaged.[8,9,11] The magnetic attraction in each sample was subsequently compared with the magnetic attraction observed in control specimen in our previous study.[3]

Figure 1. The degree of acidity (pH) of mineral water used to immerse magnetic dental attachments

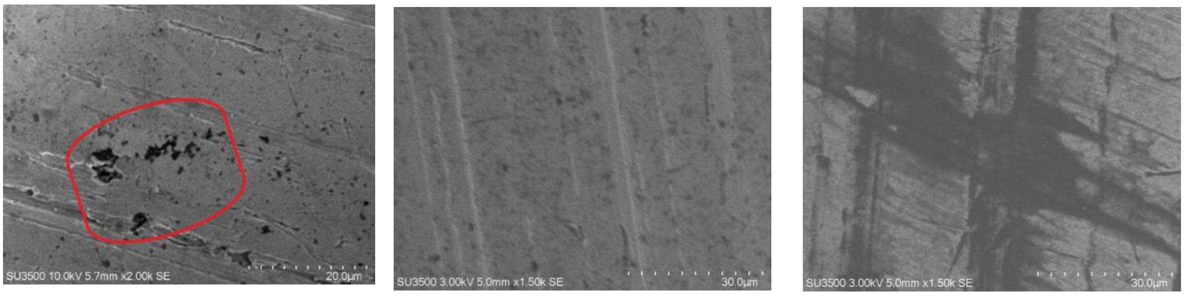
RESULTS

Based on the SEM analysis, it was observed that all the magnetic dental attachment exhibited indications of corrosion in all of the groups as illustrated in Figures 2-4. Figures 2-4 show a significant difference between the keeper and assembly surfaces that have been immersed in mineral water with the keeper and assembly surfaces in a control specimen without immersion. Visible signs of corrosion were evident on the magnetic assembly and keeper surfaces at the 7 and 14 days of immersion period. Figure 2(a) presents the results of SEM analysis performed on the assembly after immersing it in mineral water with a pH of 6.8 for a duration of 7 days, with a magnification of 2000 times, there are many small holes on the assembly surface. Figure 2(c) displays the results of SEM analysis conducted on the assembly after being immersed in mineral water with a pH of 7.5 for a period of 7 days, using a magnification of 1500 times. The analysis reveals that the surface of the assembly has undergone slight erosion.

Figure 3(a) illustrates the SEM analysis conducted on the assembly surface after immersing it in mineral water with a pH of 6.8 for a duration of 14 days, employing a magnification of 2000 times, revealed the presence of a deep groove and numerous pores appears on the assembly surface. Figure 3(c) presents the SEM analysis of the assembly after immersing it in mineral water with a pH of 7.5 for a duration of 14 days, using a magnification of 1500 times. The analysis reveals a deep and extensive erosion of the assembly surface. Figure 2(b) and 3(b) illustrates the SEM analysis conducted on the assembly surface without immersion in mineral water with 1500 times of magnification. The surface looks smoother and there are no visible pits or grooves.

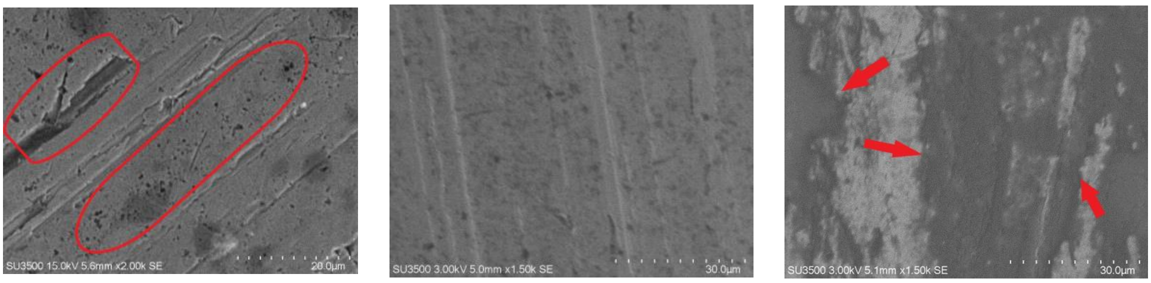
Figure 4(a) illustrates the SEM analysis of the keeper after immersing it in mineral water with a pH of 7.5 for a duration of 7 days, using a magnification of 1500 times. The analysis reveals the presence of small and deep holes, narrow and elongated grooves, as well as corrosion deposits on the surface of the keeper. Figure 4(c) illustrates the SEM analysis of the keeper after immersing it in mineral water with a pH of 7.5 for a duration of 14 days, using a magnification of 1500 times. The analysis reveals the presence of grooves and an evenly eroded surface on the keeper.

Figure 4(b) illustrates the SEM analysis of the assembly surface without immersion in mineral water, captured at a magnification of 1500 times. The surface appears smoother, and there are no visible pits or eroded areas observed.



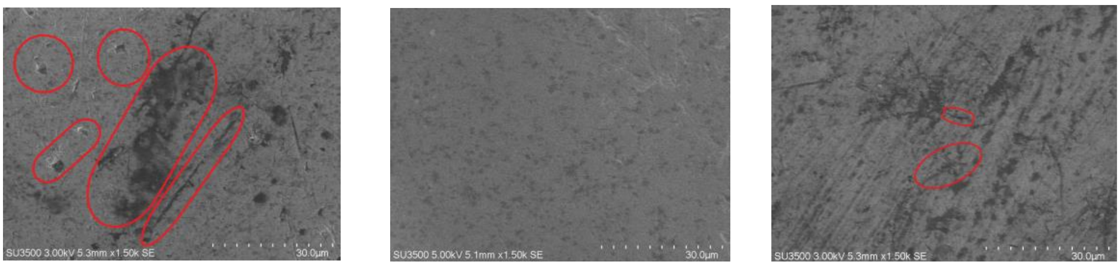
(a) **(b)** **(c)**

Figure 2. Comparison of assembly surfaces after immersion in mineral water for a duration of 7 days: with a pH of 6.8 (a), control specimen (b) and the result of immersing in pH 7.5 (c).



(a) **(b)** **(c)**

Figure 3. Comparison of assembly surfaces after immersion in mineral water for a duration of 14 days with a pH of 6.8 (a), control specimen (b) and the result of immersing in pH 7.5 (c).



(a) **(b)** **(c)**

Figure 4. Comparison of keeper surfaces after immersion in mineral water with a pH 7.5: within 7 days of immersion (a), control specimen (b), and within 14 days of immersion (c).

The magnetic attraction force decreased after 7 and 14 days of immersion in both types of mineral water compared to the control value (Table 1). The reduction in magnetic attraction was more pronounced after 14 days of immersion (Figure 5).

Table 1 The magnetic attraction force

pH of mineral water	Time of immersions (days)	Average magnetic attraction force (gf)
6.8	7	568.64
	14	469.97

7.5	7	544.41
	14	463.29
Control*	-	600.83

*Control is the value of the magnetic attraction force without immersion.
This data was taken from our previous study.[3]

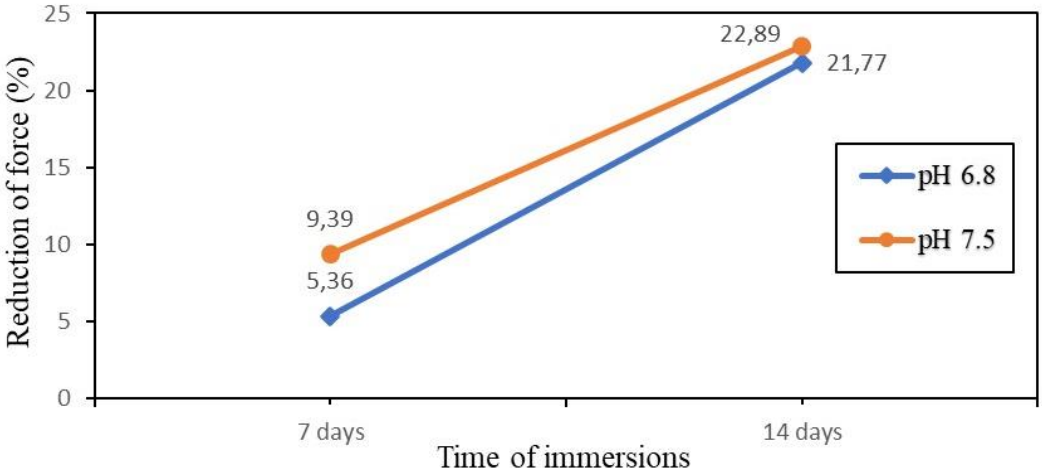


Figure 5. The reduction in magnetic attraction was greater in the 14-day immersion group compared to the 7-day immersion group, for both types of mineral water.

DISCUSSION

Corrosion on magnetic dental attachments immersed in both types of mineral water for 14 days was more extensive and caused more damage than in the 7-day immersion group. The results of this study were consistent with our previous findings.[3] Similar to this study, research by Ahmad et al.[12] and Boeckler et al.[13] showed that the longer the contact between the NdFeB magnet and the corrosive media, the corrosion process occures further, characterized by the increasing number of dissolved metal ions.

Mineral water in Indonesia is mostly sourced from volcanic mountain springs which contain lots of minerals. Mineral water can contain any combination of calcium, magnesium, sodium, potassium, chloride, bicarbonate, sulphate and specific compounds.[6] One of the mineral types that can corrode stainless steel is the chloride ion. Stainless steel is susceptible to corrosion in chloride-containing environments.[14,15] The magnetic dental attachment (Magfit DX 600, Aichi Steel, Japan) comprises of an assembly and a keeper. The Assembly is comprised of a neodymium iron boron (NdFeB) magnet, which is encapsulated with stainless steel AUM 20 and sealed hermetically through micro laser welding. On the other hand, the keeper is composed of stainless steel AUM 20. AUM 20 stainless steel is a soft magnetic stainless steel specially developed for dentistry. Ferritic stainless steel is susceptible to corrosion in environments containing chlorides.[16] However, further research is needed to find out the mineral water content that may influence the magnetic attraction.

Decrease in magnetic attraction and corrosion are two things that cannot be separated. The decrease in magnetic attraction observed in this study was attributed to the corrosion that occurred on the surface of the magnetic dental attachment. Damage to the attractive surface of the keeper and magnet assembly can reduce the magnetic attraction. In several studies on corrosion of magnetic dental attachments, it was found that the most soluble metal ion in corrosion process was iron.[12,13,17]. Iron (Fe) is one of an important element needed in magnetic properties. The dissolution of Fe ions in dental magnets causes a decrease in the magnetic attraction.

Corrosion can cause a decrease in magnetic attraction, this is in accordance with previous research.[1–3] The result of this study showed the magnetic attraction experienced a greater decrease in the 14 day immersion compared to the seven day immersion. This is in line with the level of corrosion experienced by magnetic dental attachment as observed in the SEM results. As the immersion time increases, the extent of corrosion becomes more significant, resulting in a decrease in magnetic attraction. This result is in accordance with previous studies.[1,3]

These results are in agreement with the study of Akin and Ozdemir[2] that showed magnetic attachment immersion in a 0.9% NaCl solution with a pH of 7.3 led to a higher reduction in magnetic attraction force compared to immersion in a 1% lactic acid solution with a pH of 2.3. Environment containing chlorides can cause corrosion of stainless steel and magnets. [18]. Similar to study Yiu et al.[1], the decrease in magnetic attraction was greater for magnets immersed in 0.1% sodium sulphide with a pH of 12 and artificial saliva with pH of 6.8 compared to 1% lactic acid with pH of 2.7. Saliva is a medium containing chloride which is corrosive in the oral cavity. These results indicate that the reduction in magnetic attraction does not only occur in acidic environments with low pH, but can also occur in neutral and high alkaline pH environments.

CONCLUSION

Immersion of magnetic dental attachments in mineral water can result in a decrease in magnetic attraction. Corrosion of the magnetic dental attachment is responsible for the reduction in magnetic attraction. As the immersion time in mineral water increases, the visible signs of corrosion become more pronounced, leading to a more significant decrease in magnetic attraction.

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