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Potential Outcome, Enamel Surface Roughness and Tooth Sensitivity of in Office Bleaching and at Home Bleaching

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ABSTRACT

Bleaching has become the treatment of choice for most tooth discolorations. In-office bleaching and at-home bleaching are the most frequently performed vital tooth bleaching techniques. Both of these techniques are proven to improve tooth discoloration, but unwanted effects can also occur, such as tooth sensitivity and increased tooth enamel surface roughness. Tooth sensitivity is a common side effect of bleaching procedures and the effect of bleaching on dental hard tissue is still a matter of controversy. This literature aims to conduct an integrative literature study with scientific evidence related to the potential results, enamel surface roughness, and tooth sensitivity in in-office bleaching and at-home bleaching techniques.

Method: Analyzing journals from databases such as Medline (PubMed), Ebsco, Google Scholar, textbooks, and accredited national journals.

Conclusion: This review reveals that at-home bleaching has the same potential as in-office bleaching in lightening tooth color. Higher tooth sensitivity was found in in-office bleaching, however in at-home bleaching with 20% carbamide peroxide the tooth sensitivity could be higher. An increase in tooth enamel surface roughness can occur in both techniques, but the at-home bleaching technique is more influential.

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INTRODUCTION

Dentistry nowadays is not only focused on the treatment of disease but also on fulfilling the increasing aesthetic demands.[1] Teeth are one of the most important aesthetical factors, including colour.[2] In research conducted by Samorodnizky Naveh stated that 37,3% of the study subjects were dissatisfied with the appearance of their teeth and 90% of the cause was dissatisfaction with the colour of the teeth.[3,4] Tooth discolouration is a common problem and requires treatment to get rid of the discolouration.[5]

Bleaching is the treatment of choice for most discoloured teeth because it is easier to perform, quicker, more effective, and more conservative than other treatments such as crowns and ceramic veneers.[4,6,7] The ADA (American Dental Association) states that bleaching has been the most popular aesthetic dental treatment for discoloured teeth for more than two decades.[8] AACD (American Academy of Cosmetic Dentistry) in 2015 stated that teeth whitening is the most popular aesthetic dental treatment with a percentage of 32% of 351 respondents based on a survey.[9]

Bleaching procedures can be performed internally for non-vital teeth and externally for vital teeth.[2] The most frequently performed bleaching technique for vital teeth is in-office bleaching which is done in the clinic by a dentist and at-home bleaching which is done by the patient at home, under the supervision of a dentist.[2,10,11,12]Bleaching procedures are proven to be effective in most cases of tooth discolouration. Bleaching procedures with available

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techniques can change the colour of the teeth to be whiter according to the patient's desire and need.[13] Mounika A, et al (2018) conducted a study to compare the potential of in-office bleaching and at-home bleaching techniques in whitening teeth, resulting in these two techniques proving to have potential in whitening teeth and there was no significant difference between them.[11] Jie Nie, et al (2017) conducted a similar study with different results that At-home bleaching significantly has more potential for the whitening tooth than in-office bleaching.[14]

The effect of bleaching methods and products on dental hard tissue is still a matter of controversy.[15] Abu-saq Al Yami A, et al (2019) conducted a study which proved that the at-home bleaching technique was significantly proven to increase the roughness of the enamel surface, while in-office bleaching was not significant in increasing the roughness of the enamel surface.[16] A similar study was conducted by De Abreu DR, et al (2011) with different results, that is, at-home bleaching did not significantly increase the roughness of the tooth enamel surface, while in-office bleaching significantly increased the tooth enamel surface roughness.[17]

Tooth sensitivity is a common side effect of bleaching procedures.[10,12,18,19] Tooth sensitivity that occurs in several cases of bleaching causes problems for patients. Schulte, et al found tooth sensitivity that was severe enough to cause 14% of patients to stop bleaching.[10] Moghadam, et al (2013) conducted a study which proved that there was no significant difference between at-home bleaching and in-office bleaching for the percentage and sensitivity level of the resulting teeth.[20] A similar study was conducted by Basting RT, et al (2012) with different results, namely the at-home bleaching technique has a higher prevalence and level of tooth sensitivity than in-office bleaching.[13]

LITERATURE REVIEW

Bleaching

Bleaching is one of the most popular and rapidly developing aesthetic dental treatments. It is a treatment to improve tooth colour using chemicals to oxidize organic pigments in the teeth.[11]

Bleaching techniques can generally be categorized into internal bleaching for non-vital teeth and external bleaching for vital teeth.[2] There are three external bleaching techniques for vital teeth, namely: (1) in-office bleaching; (2) at-home bleaching; (3) bleaching with OTC (over-the-counter) products.[2,21] In-office bleaching is done by dentists in clinics, while at-home bleaching is done by patients at home under the supervision of a dentist.[2,22] Bleaching with OTC products is a method that is completely done by the consumer without examination, guidance, or instructions from a dentist.[22]

In-office bleaching can provide faster whitening results by applying less material than the at-home bleaching technique to avoid soft tissue exposure and the risk of material ingestion. In-office bleaching can reduce the use of bleaching products, bleaching trays and gingival irritation that often occurs when at-home bleaching is performed.[1,19] Manufacturers provide hydrogen peroxide with a high concentration of 25-35% or 35-40% as a bleaching agent for in-office bleaching.[18,23] 35% hydrogen peroxide is the concentration most commonly used for in-office bleaching.[2,24] In-office bleaching can be assisted by applying a bleaching light or laser to help increase peroxide release.[22,24] The in-office bleaching procedure can be repeated at 1-2 week intervals.[24]

The at-home bleaching technique was first introduced by Haywood and Heymann in 1989 to the public. This technique has many advantages, including affordable cost, acceptable to patients of all socio-economic classes, safe to use, high success, and relatively easy application, namely by using special printing trays (bleaching trays).[1,2] The at-home bleaching procedure is carried out using carbamide peroxide with a concentration of 10-20% which is the same as a concentration of -6.5% hydrogen peroxide.[1,4,21] At-home bleaching uses a low concentration of bleaching agent because it is used by patients for a longer time and more frequently than in-office bleaching, so it can reduce the risk of damage to hard and soft tissue and reduce the risk of tooth sensitivity.[3] At-home bleaching can be done by injecting a bleaching agent into bleaching trays and placing it over the teeth during the day, overnight, or both.[24] Optimal results can be obtained if the bleaching trays are used at night and according to usage recommendations.[4] At-home bleaching usually takes about 2 to 4 weeks.[24] Tooth colour resulting from at-home bleaching depends on the patient's persistence in its use.[21]

Bleaching Potentials

Bleaching potential in lightening tooth colour can be assessed visually with a dental shade guide or quantitatively with a spectrophotometer. Visually assessed bleaching potential can be determined by the degree of tooth discolouration which is usually measured with a standardized dental shade guide. Assessment of bleaching potential with a dental shade guide is subjective and cannot be measured.[14]

Quantitative assessment of bleaching potential, CIE (Commission Internationale de l'Eclairage) has determined a three-parameter measurement system, namely LAB, which is a standard used globally to provide values in the form of numerical values in determining color. L* for lightness, a* for red and green, red (+) and green (-) components, while b* for yellow and blue, yellow (+) and blue (-) components.[14] The color difference can be calculated using the formula $\Delta E = [(\Delta L)2 + (\Delta a)2 + (\Delta b)2]1/2$, where ΔE is the total color difference, ΔL is L* sample minus L* standard, namely the difference in lightness and darkness, (+) lighter and (–) darker, Δa is a* sample minus standard a* i.e. difference of red and green, (+) redder and (–) greener, Δb is b* sample minus b* standard i.e. difference yellow and blue, (+) redder and (–) greener.[1]

A spectrophotometer is a measuring instrument that uses a quantitative measurement system with a three-parameter measurement system from CIE (Commission Internationale de l'Eclairage) and allows for an objective, precise and measurable assessment of tooth colour.[14] The spectrophotometer is used together with VITA Zahnfabrik to facilitate communication with patients, namely using decreasing numbers to indicate whiter tooth colour.[1]

Email Surface Rougness

Email Surface Roughness The enamel surface roughness is one of the predisposing factors for the attachment of bacteria and stains to the teeth. An increase in the surface roughness of tooth enamel can occur due to the demineralization process, but the presence of a remineralization process can reduce the surface roughness of demineralized tooth enamel.[25] Demineralization is a loss of mineral ions process in tooth enamel and damage to hydroxyapatite which is the main component of tooth enamel.[2,26] Demineralization of tooth enamel can be chemically distinguished based on the cause, namely by exposure to acids such as food or drinks that contain acids and from bacteria that are in the oral cavity.[26] During the bleaching process, the demineralization process takes place on the tooth enamel. Demineralization occurs through a diffusion process, which is the process of moving molecules or ions that dissolve in water or from within the tooth enamel due to differences in the concentration of the acidity of the tooth whitening agent on the surface of the tooth enamel and those in the tooth enamel. Solutions with high concentrations and low initial pH will diffuse into the enamel through the crystal lattice and tubular prisms which contain water and an organic matrix in the form of protein. The reaction for releasing calcium ions from tooth enamel will be higher if the pH is lower or more acidic.[2] Hydrogen ions (H+) will enter through the enamel surface when the bleaching material comes in contact with the tooth enamel, resulting in a demineralization process that causes hydroxyapatite to dissolve from the tooth enamel which will release Ca2+ ions, PO49-, OH-. Ca2+ ions, PO49-, OH- will bind with hydrogen ions and anions from acids to form complex compounds which will dissolve causing the loss of minerals from the tooth enamel surface.[3] Demineralization will result in the loss of the prism core and some of the edge prisms resulting in enamel microporosity. The missing enamel prism core will form a space in the middle of the hydroxyapatite crystal so that the enamel prism structure becomes irregular and rough. The demineralization process that occurs continuously will cause the loss of some of the enamel prisms and porosity will occur. This porosity causes damage to the enamel surface so that the tooth enamel becomes rough.[27] Increased roughness of the enamel surface after bleaching procedures can cause teeth to be more susceptible to extrinsic discoloration.[28]

The roughness of the tooth enamel surface can be identified and measured using a surface roughness tester which is also known as a profilometer and SEM (Scanning Electron Microscope).[27,29] Roughness value is expressed in Roughness average (Ra) with units of μm.[1] Measurement of tooth enamel surface roughness using a profilometer can be done by placing the specimen on a flat surface. The specimen is measured by placing the needle/stylus starting from the tip of the specimen that has been marked, then the tool is activated, and the test equipment monitor will show the specimen surface roughness value. The average value will be used as the surface roughness value.[30]

Tooth Sensitivity

Tooth sensitivity is one of the most common side effects of the bleaching procedure and usually lasts up to 4-7 days after the bleaching procedure.[10,11] Minoux and Serfaty (2008) stated that tooth sensitivity due to bleaching procedures is a temporary condition based on the level of severity, namely from none to mild in some studies and from mild to moderate in other studies.[31] The mechanism of tooth sensitivity that causes this pain is not fully understood, but it can be related to the ability of hydrogen peroxide to penetrate the tooth structure and reach the pulp chamber.[19] The microscopic surface and pores beneath the tooth enamel surface that is damaged after bleaching treatment allow rapid ingress of bleaching agent into the pulp and produce sensitivity.[10,11,23] The bleaching agent penetrates the tooth tissue to oxidize the organic components of the tooth structure, after which hydrogen peroxide and its reactive oxygen species diffuse rapidly, reaching the pulp chamber and causing the release of inflammatory mediators. Hydrogen peroxide reaches TRPA1's chemosensitive ion channels and activates interdental nerves in the pulp, so these factors may be responsible for the high risk of tooth sensitivity experienced by patients undergoing bleaching procedures.[32]

Patients undergoing bleaching treatments were interviewed in a clinical study 24 hours after the bleaching procedure was performed. Most patients say they experience pain that is described as aching or shock.[33] Pain was defined by the International Association for the Study of Pain in 1979 as an unpleasant sensory and emotional experience associated with potential tissue damage. Pain is an experience that is felt by the patient, so pain is usually assessed from direct information by the patient subjectively. The visual analogue scale (VAS) is used for pain assessment.[10]

DISCUSSION

Tooth discolouration is a common thing and makes people need treatment to improve the colour of their teeth.[5] Bleaching is a safe, conservative treatment and has been shown to have the potential to improve tooth colour.[12,14] The most frequently performed bleaching technique for vital teeth is in-office bleaching and at-home bleaching.[20] At-home bleaching is a popular technique with a high success rate, easy to use and more affordable cost compared to in-office bleaching.[2,16,34] This technique usually takes 2 to 4 weeks using a bleaching tray, but some patients cannot adapt well to doing at-home bleaching, such as using a bleaching tray and waiting to get the desired results for a longer time compared to in-office

bleaching.[24,34] In-office bleaching is a bleaching technique that uses high concentrations of hydrogen peroxide and is performed by dentists in dental clinics.[20] Despite the advantages that result from bleaching teeth, there are downsides. desirable, such as tooth sensitivity and its effect on dental hard tissue.[15,16] The resulting bleaching potential in improving tooth colour between in-office bleaching and at-home bleaching techniques has been studied by several researchers, such as Moghadam, et al (2013), Jie Nie, et al (2017), and Mounika A, et al (2018), shown in Table 1. The research conducted by Jie Nie, et al (2017) had different results from the research conducted by Moghadam, et al (2013) and Mounika A, et al (2018). Jie Nie, et al proved that at-home bleaching has significantly more potential in improving tooth colour when compared to in-office bleaching, whereas in the research of Moghadam, et al (2013) and Mounika A, et al (2018) that there was no significant difference between both techniques and both techniques have the potential to improve tooth colour.[11,14,20] The difference in the research results of Jie Nie, et al (2017) with Moghadam, et al (2013) and Mounika A, et al (2018) is thought to be due to differences in concentration, total treatment time and research methods. Research by Jie Nie, et al (2017) on at-home bleaching, the total application time is much longer, namely 96 hours (8 hours every day for 12 days), while the at-home bleaching technique in Moghadam's research, et al (2013) with a total time 56 hours of application (4 hours daily for 14 days) and both were compared with the in-office bleaching technique with the same total time of 45 minutes of application. The difference in total treatment time is thought to be the cause of the difference in the results of the two studies. Research by Jie Nie, et al (2017) with the method of dividing subjects into two groups, group 1 with in-office bleaching and group 2 with at-home bleaching differed from the method used by Moghadam, et al (2013) and Mounika A, et al (2018), namely split-mouth study design. The split-mouth study design that was carried out in both studies was to perform in-office bleaching and at-home bleaching techniques on the same subject, by dividing both the subject's upper and lower jaws or one jaw with a different region. This method can reduce the influence of variables, such as patient habits observed in bleaching treatments.[11,14,20]

The side effects of bleaching on tooth enamel, in increasing the roughness of the tooth enamel surface between in-office bleaching techniques and at-home bleaching techniques have been studied by several researchers, namely, De Abreu, et al (2011), Polydorou O, et al (2018), and Abu - saq Al Yami, et al (2019), as in Table 2. De Abreu, et al (2011) conducted a study with results proving that there was no significant difference between at-home bleaching and in-office bleaching using hydrogen peroxide with various concentrations, but the research group using the in-office bleaching technique using 38% hydrogen peroxide was shown to increase the enamel surface roughness value significantly, while the other group did not prove to be significant in increasing the enamel surface roughness value. Measurement of pH at several concentrations of bleaching material in this study resulted in 38% hydrogen peroxide with the in-office bleaching technique having the lowest pH this is thought to cause a significant increase in the enamel surface roughness value. Soaking samples in artificial saliva for 14 days in this study can affect the reduction of tooth enamel surface roughness in in-office bleaching with 38% hydrogen peroxide and is almost similar to the enamel surface roughness value before treatment because it can help increase the pH and the remineralization process that occurs.[17]

Polydorou O, et al (2018) conducted a study with results proving that in-office bleaching with 40% hydrogen peroxide at-home bleaching with 6% carbamide peroxide and at-home bleaching with 16% carbamide peroxide proved to significantly increase the roughness of the enamel surface, however, there is no significant difference between them. Changes in enamel surface roughness in in-office bleaching significantly increased after the first 2 weeks of treatment and did not increase again after 8 weeks of treatment. Changes in enamel surface roughness in at-home bleaching significantly increased after 2 weeks of treatment and continued to increase after 8 weeks of treatment, resulting in higher enamel surface roughness compared to in-office bleaching. This study used a bleaching agent with an almost neutral pH, so this study shows that apart from pH, application time is an important parameter of its effect on the enamel surface roughness. The longer the application time of the bleaching agent will further increase the surface roughness of the tooth enamel. Mondelli, et al (2009) through their research also showed that application time is an important factor in the bleaching effect on tooth enamel.[15]

Abu-saq Al Yami A, et al (2019) conducted a study with results proving that at-home bleaching with 15% carbamide peroxide could significantly increase the enamel surface roughness value, while in-office bleaching with 40% hydrogen peroxide did not significantly increase the enamel surface roughness. tooth enamel surface roughness. Both of these bleaching techniques resulted in a higher surface roughness in enamel when compared to the control, but in-office bleaching did not show a significantly higher surface roughness value. Although the in-office bleaching in this study contained 40% hydrogen peroxide, additional materials such as fluoride could help the remineralization process, so it did not show a significant increase in the enamel surface roughness. At-home bleaching with a low concentration, namely 15% carbamide peroxide was used for a long time and a long duration in this study, so the contact time between the at-home bleaching agent and the teeth was much longer than in-office bleaching. Cadenaro et al, in 2006 through his research proved that in-office bleaching had no significant effect on tooth surface roughness, this supports the results of research by Abu-saq Al Yami A, et al (2019).[16]

Research that aims to compare tooth sensitivity in at-home bleaching and in-office bleaching techniques has been

carried out by several researchers, namely Basting RT (2012), Tay LY, et al (2012), Moghadam, et al (2013), and Mounika A, et al (2018) as in Table 3. Basting RT, et al (2012) conducted a study which proved that the prevalence and intensity level of tooth sensitivity in the at-home bleaching technique with 20% carbamide peroxide was higher than in-office bleaching technique with hydrogen peroxide 35% and 38%. The prevalence of tooth sensitivity in these two techniques was 35 out of 81 total subjects. At-home bleaching with 20% carbamide peroxide, namely 15 out of 35 subjects consisting of 10 subjects with mild intensity (mild), subjects with moderate intensity (moderate) and 1 subject with severe intensity (severe). The prevalence of tooth sensitivity in in-office bleaching with 35% hydrogen peroxide was 10 out of 35 subjects with 6 subjects of mild intensity, 3 subjects of moderate intensity, and 1 subject of severe intensity. The prevalence of tooth sensitivity in in-office bleaching with 38% hydrogen peroxide was 3 out of 35 subjects with 2 subjects of mild intensity, and 1 subject of moderate intensity. This study shows that tooth sensitivity is not only related to the high concentration of peroxide used in the in-office bleaching technique but also related to the time the bleaching agent is applied in contact with the tooth structure.[13]

Tay LY, et al (2012) conducted a study with different results from the research conducted by Basting RT, et al (2012). This study proves that the intensity of tooth sensitivity and prevalence of subjects who experience tooth sensitivity in in-office bleaching with 35% hydrogen peroxide is higher than at-home bleaching with 16% carbamide peroxide, but the difference in prevalence is not significant. Subjects who experienced sensitivity in in-office bleaching were 26 people with a mild to moderate intensity level, while in at-home bleaching there were 20 people with a mild intensity level.[34]

The research by Moghadam et al, (2013) regarding the comparison between the at-home bleaching and in-office bleaching techniques discussed previously, also aims to evaluate the tooth sensitivity that occurs in both techniques. The results of this study are different from previous research by Basting RT, et al (2012). This study proves that the prevalence of subjects experiencing tooth sensitivity in the in-office bleaching technique with 38% hydrogen peroxide was higher, reaching 57.1% compared to at-home bleaching with 15% carbamide peroxide, which reached 42.9% of the study subjects. not significant.[20]

The research by Mounika A, et al (2018), a study regarding the comparison between the in-office bleaching and at-home bleaching techniques discussed earlier, also aims to compare the tooth sensitivity that occurs in the two techniques. The results of this study support the results of research from Tay LY, et al (2012). This study proves that the intensity level of tooth sensitivity felt by subjects in in-office bleaching with 35% hydrogen peroxide is significantly higher than at-home bleaching with 16% carbamide peroxide. Subjects experiencing sensitivity to in-office bleaching reported moderate to severe intensity.[11]

Research conducted by Basting et al, (2012) had different results from research conducted by Tay LY, et al (2012), Moghadam et al, (2013) and Mounika A, et al (2018). This difference is thought to be due to differences in the concentration of the bleaching agent used in the study by Basting et al, (2012) and that used in the other three studies. Basting et al., proved that tooth sensitivity resulting from at-home bleaching has both a higher prevalence and intensity than in-office bleaching. The study by Basting et al. used carbamide peroxide with a high enough concentration to be an at-home bleaching agent, namely 20%, whereas Tay's study, et al. (2012) used 16% carbamide peroxide, Moghadam et al.'s research (2013) used 15% carbamide peroxide, and research by Mounika A, et al (2018) using 16% carbamide peroxide. Cooper et al., in 1992 stated that a very fast flow of hydrogen peroxide occurs through the tooth structure within 15 minutes after application, hydrogen peroxide can be detected in the pulp, so using a higher concentration of hydrogen peroxide allows for a greater number of reactive molecules. to the pulp, leading to a more intense inflammatory response and tooth sensitivity. Differences in symptoms felt by each person who is assessed subjectively can also be a reason for differences in results.[1,13,20,34]

Table 1. The results of the study related to the potential of bleaching in whitening teeth, in in-office bleaching and at-home bleaching techniques

Researcher	Bleaching Technique	Bleaching Material	Bleaching Protocols	Result
Moghadam,et al (2013)	*In-office Bleaching*	38% Hydrogen Peroxide (White Extra)	1 day (3x applications, each for 15 minutes) Total treatment time: 45 minutes	There is no difference in potential bleaching results (value ΔE1), between at-home bleaching and in-office bleaching techniques. P>0,05
	At-home Bleaching	15% Carbamide Peroxide (Opalescence)	14 days (4 hours a day, every night) Total treatment time : 56 hours	

Jie Nie, et al (2017)	*In-office Bleaching*	38% Hydrogen Peroxide (Opalescence)	1 day (3x applications, each for 15 minutes) Total treatment time: 45 minutes	There is a difference in potential bleaching results (ΔE value), between at-home bleaching and in-office bleaching techniques. At-home bleaching has more potential to whiten tooth color compared to in-office bleaching. P<0,05
	At-home Bleaching	10% Carbamide Peroxide (Opalescence)	12 days (8 hours a day, every night) Total treatment time: 96 hours	
Mounika A, et al (2018)	*In-office Bleaching*	35% Hydrogen Peroxide (Pola Office)	3 days (7 days interval) (3x applications, 15 minutes each) Total treatment time: 2 hours 15 minutes	There is no significant difference between in-office bleaching and at-home bleaching techniques based on their potential to improve tooth color. P > 0,05
	At-home Bleaching	16% Carbamide Peroxide (Pola night)	21 days (8 hours a day, every night) Total treatment time: 168 hours	

Table 2. Research results related to enamel surface roughness as a side effect of bleaching in in-office bleaching and at-home bleaching techniques.

Researcher	Bleaching Technique	Bleaching Material	Bleaching Protocols	Result
De Abreu, et al (2011)	*In-office Bleaching*	35% Hydrogen Peroxide (Pola Office)	3 days (with 7-day intervals) (3x applications of 8 minutes each) Total treatment: 72 minutes	There was no significant difference (P > 0.05) between in-office bleaching and at-home bleaching in the enamel surface roughness values. In the statistical test for each group, only the group with the in-office bleaching technique (38% Hydrogen Peroxide) significantly (P < 0.05) increased the enamel surface roughness.
		38% Hydrogen Peroxide (Opalescence)		
	At-home Bleaching	7,5% Hydrogen Peroxide (Pola Day)	21 days (30 minutes a day) Total treatment time: 5 hours 25 minutes	
		9,5% Hydrogen Peroxide (Pola Day)		
Polydorou O, et al (2018)	*In-office Bleaching*	40% Hydrogen Peroxide (Opalescence)	8 weeks (3x applications, 20 minutes each)	In-office bleaching and at-home bleaching techniques significantly (P < 0.05) increased the enamel surface roughness and there was a significant difference (P < 0.05) between in-office bleaching and at-home bleaching, after 8 weeks of treatment.
	At-home Bleaching	16% Carbamide Peroxide (Opalescence)	8 weeks (6 hours a day)	
		6% Hydrogen Peroxide (Vivastyle Paint on Plus)	8 weeks (2x applications of 10 minutes each)	
Abu-saq Al Yami, et al (2019)	*In-office Bleaching*	40% Hydrogen Peroxide (Opalescence Boost)	1 day (2x applications of 20 minutes each) Total treatment time: 40 minutes	There was a significant difference (P < 0.05) between the at-home bleaching group and the control group and there was no significant difference (P > 0.05) between the in-office bleaching group and the control group.
	At-home Bleaching	15% Carbamide Peroxide (Opalescence Home)	4 days (2 hours a day) Total treatment time: 8 hours	

Table 3. The results of the study related to tooth sensitivity as a side effect of bleaching in in-office bleaching and at-home bleaching techniques

Researcher	Bleaching Technique	Bleaching Material	Bleaching Protocols	Result
Basting RT, et al (2012)	*In-office Bleaching*	38% Hydrogen Peroxide (Opalescence)	3 days (with 7-day intervals) (3x applications of 8 minutes each) Total treatment: 72 minutes	The prevalence and intensity level of tooth sensitivity in at-home bleaching technique with 20% carbamide peroxide is higher than in-office bleaching with 35% and 38% hydrogen peroxide. P < 0.05
		35% Hydrogen Peroxide (Pola Office)		
	At-home Bleaching	10% Carbamide Peroxide (Opalescence)	21 days (2 hours a day) Total treatment time: 42 hours	
		20% Carbamide Peroxide (Opalescence)		
Tay LY, et al (2012)	*In-office Bleaching*	35% Hydrogen Peroxide	2 days (7 days interval) (3x applications of 15 minutes each) Total treatment time: 90 minutes	The intensity level of tooth sensitivity in in-office bleaching technique with 35% hydrogen peroxide was significantly (P <0.05) higher than at-home bleaching with 15% carbamide peroxide, and the prevalence in in-office bleaching was higher than at-home bleaching but not significant (P > 0.05).
	At-home Bleaching	16% Carbamide Peroxide	28 days (6 hours a day) Total treatment time: 168 hours	
Moghadam, et al (2013)	*In-office Bleaching*	38% Hydrogen Peroxide (White Extra)	1 day (3x applications, 15 minutes each) Total treatment time: 45 minutes	The prevalence of tooth sensitivity in in-office bleaching technique with 38% hydrogen peroxide was higher than at-home bleaching with 15% carbamide peroxide, but the difference was not significant. P > 0.05
	At-home Bleaching	15% Carbamide Peroxide (Opalescence)	14 days (4 hours a day) Total treatment time: 56 hours	
Mounika A, et al (2018)	*In-office Bleaching*	35% Hydrogen Peroxide (Pola Office)	3 days (7 days interval) (3x applications of 15 minutes each) Total treatment time: 135 minutes	The intensity level of tooth sensitivity in in-office bleaching technique with 35% hydrogen peroxide was significantly (P < 0.05) higher than at-home bleaching with 16% carbamide peroxide.
	At-home Bleaching	16% Carbamide Peroxide (Pola night)	21 days (8 hours a day) Total treatment time: 168 hours	

CONCLUSION

Bleaching as a treatment to improve tooth colour has a variety of techniques. In-office bleaching and at-home bleaching techniques are the techniques most often used in external bleaching techniques for vital teeth. The potential of bleaching to improve tooth colour has been proven based on various studies that have been conducted, but some effects arise such as tooth sensitivity and increased tooth enamel surface roughness. At-home bleaching is proven to have the same potential as in-office bleaching in improving tooth colour, but it still requires a longer treatment time. Tooth sensitivity that occurs in in-office bleaching is proven to have a higher prevalence and intensity level compared to at-home bleaching, but at-home bleaching with 20% carbamide peroxide can exceed the prevalence and intensity level of tooth sensitivity that occurs in in-office bleaching. Increased roughness of the tooth enamel surface has been shown to occur in in-office bleaching and at-home bleaching techniques. The at-home bleaching technique is more influential in increasing the roughness of the tooth enamel surface, because apart from pH, the total treatment time is also a contributing factor. The decrease in the surface roughness

of the tooth enamel can be affected by the presence of saliva and fluoride contained in the bleaching agent.

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