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Hemostatic agents in orthodontics: A review

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ABSTRACT

Introduction and Aims: Loss of the bracket-tooth bond is one of the most common complaints of patients during orthodontic treatment. Various factors play a role in preventing the loss of such a strong bond between the bracket and tooth, one of which is the maintenance of proper isolation and prevention of contamination of tooth surface with blood during the surgical exposure of the impacted tooth. In case of bleeding during disimpaction treatment, the use of hemostatic agents might decrease the odds of tooth surface contamination with blood, resulting in a strong bond. This study aimed to evaluate the effect of different hemostatic agents on the bond between the bracket and tooth.

Materials and Methods: Science Direct, PubMed, and Google Scholar databases were searched for relevant previous studies published from 2010 to 2020. These studies' titles and abstracts were evaluated for inclusion criteria. In vivo and in vitro studies evaluating the effect of hemostatic agents on the bracket-tooth bond were included.

Results: Eight studies were included in the study based on inclusion criteria; five studies were in vitro, and two were in vivo; one study had both designs. Of in vitro studies evaluating the bond strength, five studies reported a higher bond strength in the control group than the group in which the tooth surfaces were contaminated with a hemostatic agent; besides, the bond strength in the hemostatic agent group was higher than that in the group in which the tooth surfaces were contaminated with blood. Of in vivo studies, two studies evaluated bracket failure as a criterion to evaluate bonding quality. In one of these studies, bracket failure in the control groups was more than the hemostatic agent group, and in the other study, it was more prevalent in the hemostatic agent group than the control groups. Studies comparing different hemostatic agents did not report any significant differences in bonding quality.

Conclusion: It appears that the use of hemostatic agents in disimpaction treatments can prevent contamination of tooth surface with blood, increasing the bond strength between the bracket and tooth; however, care should be exercised to prevent tooth surface contamination with hemostatic agents.

Keywords: Bracket; Orthodontic bonding; Hemostatic agent; Bond strength; Adhesive.

Introduction

One of the standard techniques to align teeth is to use fixed appliances and bonding of brackets to tooth surfaces. Fixed orthodontic treatment usually takes two years. The loss of tooth-bracket bonding during this period increases costs and the materials used and leads to patient discomfort and lengthened treatment

[1]. Previous studies have shown that favorable bonding entails a proper bond strength to prevent bracket debonding during treatment [2]. Many studies have evaluated factors affecting the bond strength between brackets and tooth surfaces, including enamel surface preparation techniques, different adhesive systems, and bracket-related factors, including bracket size and bracket base design [3]. Adhesives currently used to bond brackets to tooth surfaces include four general categories: 1) composites that are a combination of resin and matrix; 2) glass-ionomers that are a mixture of powder and fluid; 3) polyacid-modified composite resins (compomers) introduced in recent years; 4) resin-modified glass-ionomers (RMGI) produced by modifying the glass-ionomer structure. Composite resin and glass-ionomer adhesive can be cured through self-cured chemical reactions or blue light irradiation [4]. Composite resins and RMGI are the most commonly used orthodontic adhesives [5]. Of all the available adhesives, Transbond XT is currently the gold standard for bonding orthodontic brackets [6].

Another factor affecting the bonding of orthodontic brackets is the necessity of bonding in a dry environment [7]. Bonding is a technique-sensitive process, and it is necessary to maintain isolation to achieve a favorable bond between the tooth surface and resin. Surface contamination in any bonding steps prevents clinical success [8]. An example of these surface contaminations is the contamination of tooth surface with blood during surgery to expose an impacted tooth [9]. Impacted teeth might cause odontogenic infections, periodontal diseases, cysts, tumors, and dental caries. Therefore, it is necessary to treat these conditions. The maxillary and mandibular third molars are the most common impacted teeth, followed by maxillary canines, with a prevalence of 1-3% in different populations [10,11]. Disimpaction treatment of the maxillary impacted canine has been recommended due to its importance in function and esthetics. On the other hand, contamination of the surface of this tooth with blood during surgery might significantly decrease the bond strength of orthodontic brackets. Hemostatic agents should be used to prevent leakage of blood to the bonding area to solve this problem [9]. Hemostatic agents are broadly divided into two categories: adrenergic agents (vasoconstrictors) and astringents (blood clotting agents) [12]. Adrenergic agents, such as epinephrine, activate α_1 sympathetic receptors on the peripheral blood vessels, decreasing local blood perfusion by constricting the blood vessels. Astringents, such as aluminum chloride, ferric sulfate, and zinc chloride, are metallic salts that precipitate proteins, coagulating blood and stopping hemorrhage [13]. Hemostatic agents stop profuse bleeding resulting from the rupture or incision of capillaries and arterioles. 25% aluminum chloride (with a proprietary name of Viscostat Clear) and 20% ferric sulfate (with a proprietary name of Viscostat) are the preferred astringents used by dentists due to their minimal tissue damage and ease of use [14-16]. Some other hemostatic agents include ankaferd blood stopper (ABS), calcium sulfate, and H_2O_2 [17-19].

ABS is a herbal extract medicinal agent used in Turkish traditional medicine as a hemostatic agent. This product is a combination of Thymus vulgaris, Glycyrrhiza glabra, Vitis vinifera, Alpinia officinarum, and Urtica dioica herbs, each of which exerts some effects on the endothelium, blood cells, angiogenesis, cellular proliferation, and cellular mediators [20]. Calcium sulfate (CaS) is a biocompatible agent with a long history in various medical fields. It is rapidly absorbed and leaves calcium phosphate residues that improve bone regeneration and hemostasis [21]. Hydrogen peroxide (H_2O_2) is used as an antiseptic and antimicrobial agent. It is also used to cleanse surgical incisions for better localization of hemorrhage. This agent destroys fibroblasts in the wound and stops local blood flow [22,23]. As mentioned previously, the use of hemostatic agents prevents the bonding surface's contamination by stopping hemorrhage [24]. However, these agents themselves might contaminate the bonding surface, decreasing the bond strength [12]. Several studies have evaluated the effect of hemostatic agents on the bonding properties in orthodontics. Given the importance of the bonding process in treating impacted teeth, the present review study aimed to evaluate different hemostatic agents and their effect on bonding in orthodontic treatment.

Materials and Methods

The databases used to collect data consisted of Science Direct, PubMed, and Google Scholar. The key words bracket, orthodontic bonding, hemostatic agent, bond strength, and adhesive, and a combination of them were used to collect studies. Of all the studies brought up by the search, relevant articles published from 2010 to 2020, irrespective of the database, were evaluated. After the initial search, 113 articles were found in Goggle Scholar, 6l in Pubmed, and 32 in Science Direct.

Inclusion criteria

- Studies comparing at least two study groups or a study group and a control group.
- Studies of at least 5 animals or human subjects in each group.
- Studies evaluating the effect of at least one hemostatic agent with adequate statistical analyses.
- Studies published in English.

Results

Eight studies were included in the present study based on inclusion criteria (Table 1). Five studies were in vitro, [9,18,25-27] two were in vivo, [19,28] and one was in vivo and in vitro [17]. In the in vitro studies, five used extracted human teeth, [9,17,18,25,27] and one used bovine incisors [26]. Of those using human teeth, four studies evaluated premolar teeth, and one evaluated third molar teeth. Of in vivo studies, one study evaluated maxillary canines (n=52), mandibular canines (n-=12), and premolar teeth (n=2) [19]. One study evaluated only maxillary canines [28], and one study evaluated only premolar teeth [17].

The included studies used totally six different hemostatic agents with TbXT and Light Bond adhesive systems. Four studies used the ABS hemostatic agent, [9,18,25,26] and three studies used epinephrine (adrenaline) [17,18,28]. Viscostat, calcium sulfate, Tranexamic acid, Ethamsylate and H_2O_2 each were used in one study [17,19,27]. Four studies compared the effects of hemostatic agents [17,18,27,28]. In the included studies, no standard technique was found to irrigate the tooth surface after applying the hemostatic agent. In four studies, the hemostatic agent was air-dried only [9,18,26,27]. In one study, after applying the hemostatic agent, the bonding surface was first irrigated for 30 seconds and then dried with air spray [17]. In one study, some groups of samples were air-dried, and in some other groups, they were cleaned with a moist piece of surgical gauze [25]. Among the in vivo studies one of them used dried gauze pieces and an excavator to remove the hemostatic agent [19]. In one study, the bonding surface was irrigated with sterile saline solution [28]. One study did not report the method used for irrigation [17]. In the included studies, six of them used conventional etch-and-rinse and light-cure primer system [17,18,25-28]. One study used a one-step self-etching primer system [25]. One study was just used etch and rinse [9] and One study did not mention the system used [19]. Besides, six studies used TbXT, [17,18,25-28] and in one study, Light Bond was used as adhesives [9]. One study did not mention the type of adhesive used [19]. The shear bond strength test (SBS) was used in all the in vitro studies to evaluate the bonding quality [9,17,18,25-27]. Two in vivo studies evaluated bracket failure, [17,19] and one study evaluated only the bonding time of all the bonding characteristics [28].

Of six studies that used SBS as a criterion for the evaluation of bonding quality, five studies reported significantly higher SBS in the control group than the groups in which a hemostatic agent was used. All these studies used conventional etch-and-rinse and light-cure primer system [9,17,18,26,27]. In one study which used the system above for some groups and the one-step self-etching primer system for some others is shown that the control group's SBS was similar to that in the hemostatic agent group in which the conventional etch-and-rinse and light-cure primer system was used. The hemostatic group's SBS in association with the one-step self-etching primer system was less than that in the control group [25]. Two in vivo studies evaluated bracket failure as a criterion to evaluate the bonding quality. In one of these studies, bracket failure in the control group was higher than the hemostatic agent group, [19] and in the other study, bracket failure was higher in the hemostatic agent group than that in the control group [17]. Studies comparing different types of hemostatic agents did not report any significant differences in bonding quality [17,18,28].

Table 1. Review studies.

Source	Title	Study group	Hemostatic agent	Contamintion Situation	Cleansing the surface after appling hemostatic agent	Etching type and primer system	Adhesive	Bonding test	Attachment part	Conclusion
Trakyali et al 2010 [26]	Plant Extract Ankaferd Blood Stopper Effect on Bond Strength	60 extracted bovine permanent mandibular incisors in 3 groups. Gp1 1:contaminated with ABS Gp 2:contaminated with blood Gp 3:no contamination	ABS2	After etching and before applying primer hemostatic contamination was done	No cleansing air dried only	conventional etch-and-rinse system and a light-cure primer (TbXT primer)	TbXT3	SBS4	mesh-based mandibular central incisor brackets with a 0.018-inch slot (Roth Generous brackets, GAC International Inc, Bohemia, NY)	SBS values of Control group> SBS values of ABS contaminated group> SBS values of blood contaminated group
Scarano et al 2010 [19]	Application of calcium sulfate in surgical-orthodontic treatment of impacted teeth: a new procedure to control hemostasis	43 patients with 66 teeth are included into the study.for 33 teeth as test group calcium sulfate is used for hemostasis and for 33 teeth as control group gauze is used for hemostasis.	CaS5	Before etching hemostatic contamination was done	With dry gauze and an excavator extra CaS is removed.	Not mentioned	Not mentioned	Detachment of the bracket during intra-surgical traction test and during an orthodontic traction test.	Bracket(type of bracket did not mentioned)	Bracket detachment of control group> Bracket detachment of test group
Güngör et al 2013 [9]	Effects of contamination by either blood or a hemostatic agent on the shear bond strength of orthodontic buttons	45 extracted impacted third molars in 3 groups Gp I, human blood was applied to the tooth surface and airdried; Gp II, blood stopper was applied to the surface and air-dried; and Gp III, neither blood stopper nor blood was applied	ABS	After etching and before applying primer hemostatic contamination was done	No cleansing air dried only	Total etch(etch and rinse)	Light bond	SBS	Orthodontic buttons (9.6 mm2 surface area; G & H Wire Company, Greenwood, IN, USA)	SBS values of Control group> SBS values of ABS contaminated group> SBS values of blood contaminated group

Oksayan et al 2015 [18]	Effects of hemostatic agents on shear bond strength of orthodontic brackets	57 extracted human premolars in four groups: Gp I, control-group Gp II, contaminated with blood Gp III, contaminated with epinephrine Gp IV, contamination with ABS	ABS Epi6	Before etching and applying primer hemostatic contamination was done.	No cleansing air dried only	conventional etch-and-rinse system and a light-cure primer (TbXT primer)	TbXT	SBS	Metal brackets (Master Series, American Orthodontics, Sheboygan, WI, USA)	SBS values of Control group>SBS values of ABS contaminated group=SBS values of Epi contaminated group>SBS values of blood contaminated group
Akendiz et al 2015 [25]	Using Hemostatic Agents During Orthodontic Bonding: An In Vitro Study	108 extracted human premolars in 6 groups. Gps 1to 3 used conventional etch-and-rinse system and a light-cure primer and Gps 4 to 6 used 1-step self-etching primer also: Group1&4:no contamination Group2&5:ABS contamination wirh using air drying method Group3&6: ABS contamination using Wet surgical gauze method Group1&4:no contamination Group2&5:ABS contamination wirh using air drying method Group3&6: ABS contamination using Wet surgical gauze method	ABS	Before etching and applying primer hemostatic contamination was done.	Air dried or using wet surgical gauze	conventional etch-and-rinse system and a light-cure primer (TbXT primer) & 1-step self-etching primer (Tb plus7 self-etching primer)	TbXT	SBS	Mesh-based stainless steel(Gemini, 3M-Unitek, Monrovia, CA, USA), with a 0.022-inch slot and a surface area of 9.08 mm2	No contamintation and using conventional etch-and-rinse system and a light-cure primer=No contamination and using 1-step selfetching primer =contamination with ABS and using conventional etch-and-rinse system> contamination with ABS and using 1-step selfetching primer Also: cleansing the ABS-contaminated bonding surface with wet surgical gauze increased the bond strength to normal values

Karabekiroğlu et al 2017 [17]	Do hemostatic agents affect shear bond strength and clinical bond failure rate of orthodontic brackets?	In vitro study: 100 human maxillary premolars in 5 groups: Gp 1: no contamination Gp 2: contaminated with blood Gp 3: contaminated with blood and then viscostat Gp 4:contaminated with blood and then epinephrine Gp 5: contaminated with blood and then H2O2	Viscostat8 Epi H2O2	Before etching and applying primer hemostatic contamination was done.	Rinsing for 30s and then air dried	Conventional etch-and-rinse system and a light-cure primer (TbXT primer)	TbXT	SBS	metal brackets (0.018-inch slot; Roth–Equilibrium®, Dentaurum, Pforzheim, Germany)	SBS values of Control group>SBS values of Viscostat contaminated group=SBS values of Epi contaminated group= SBS values of H2O2 contaminated group> SBS values of blood contaminated group
		In vivo study:99 subjects with totally 354 teeth are included to the study and divided into 4 groups including control group, viscostat used group, epinephrine used group and H2O2	Viscostat Epi H2O2	Before etching and applying primer hemostatic contamination was done.	Not mentioned	Conventional etch-and-rinse system and a light-cure primer (TbXT primer)	TbXT	Bracket failure rate	0.018-inch pre-adjusted metal bracket and tubes were used	failure rate of: Control group< Viscostat group=Epi group=H2O2 group
Adilogğlu et al 2018 [27]	Hemostatic effects of adrenaline and Ankaferd (blood stopper) during orthodontic attachment bonding	20 patients in 2 groups Group A was treated with adrenaline (ADR) and group B was treated with ABS	ABS ADR9	Before etching and applying primer hemostatic contamination was done.	Surgery site was irrigated with sterile saline for removing ABS and ADR	conventional etch-and-rinse system and a light-cure primer (TbXT primer)	TbXT	Bonding time10	Gold chain	Bonding time of: ABS treated group=ADR treated group

1- Gp: group. 2- ABS: Ankaferd Blood Stopper. 3- TBXT: Transbond XT primer. 4- SBS: Shear bond strength. 5- CaS: Calcium sulfate. 6- Epi: Epinephrin(Adrenaline). 7- TB plus: Transbond plus self-etching primer. 8- Viscostat: 20% ferric sulfate. 9- ADR: Adrenaline (Epinephrine). 10- Bonding time: bonding time is started with the application of acid gel and stopped after the light curing.

Discussion

Only a few review studies have evaluated hemostatic agents in dentistry, and no study has evaluated these agents in orthodontics. Bandi et al (2017) evaluated ferric sulfate as a hemostatic agent in different dental fields, including pediatrics, endodontics, and restorative dentistry. In that study, no tables were presented to compare different studies. Besides, the review did not evaluate the effect of hemostatic agents on bonding [29]. Tarighi et al (2014) evaluated the different hemostatic agents used in dentistry, reporting that aluminum chloride and 15–25% ferric sulfate with 3–10-minute application time was the most commonly used hemostatic agents in dentistry [16]. The study carried out by Bernades (2014) was more similar to the present study. The study evaluated the effect of hemostatic agents on enamel and dentin bonding in 20 studies. The study presented a table, similar to the present study, to compare the characteristics of studies. In contrast to other review studies which only investigated the effect of hemostatic agents on dentin, this study evaluated the effect of these agents on enamel, too, in addition to their effect on dentin. Therefore, in contrast to the present study, that study did not aim to evaluate enamel bonding of orthodontic brackets; instead, it evaluated bonding on enamel generally and in a limited manner. In that study, of all the 20 studies selected, only two studies evaluated enamel, and 18 others evaluated the effect of hemostatic agents on dentin bonding quality. In orthodontic treatments, attachments are always bonded on the enamel, and evaluation of dentin bonding cannot help investigate the bonding of orthodontic brackets [12].

It is vitally important to achieve a strong and durable bond between the bracket and tooth structure for successful orthodontic treatment. In disimpaction treatments, contamination of the tooth surface with blood can pose a problem for bracket bonding. Therefore, the clinician must be aware of the management of such conditions. Using hemostatic agents during treatment, might be helpful in some conditions. Therefore, it is necessary to evaluate the effect of hemostatic agents on orthodontic bonding. However, only a limited number of studies have evaluated such an effect, and no study has compared these studies and the different hemostatic agents used in dentistry. The present study is the first review study to evaluate and compare these agents. In the present review study, studies evaluating the effect of one or several hemostatic agents in orthodontic treatment were selected so that their comparison would provide a general conclusion on the use of hemostatic agents during the surgery and orthodontic treatment of impacted teeth. The study by Trakyali et al was the first to evaluate the effect of a hemostatic agent on orthodontic bracket bonding. One of the advantages of that study was the use of an aging process to simulate the conditions of orthodontic brackets in the oral cavity before the SBS test. However, that study used bovine mandibular incisor teeth instead of human teeth, and mandibular incisor brackets were used accordingly. Although it was said in this study that bovine tooth has the most similarity to human tooth, but little difference between bovine and human enamel such as density, thickness and percentage of hydroxyapatite and other microscopic structures might cause significant effects on enamel-bracket binding. Therefor its might be better to use human tooth to simulate clinical conditions. Besides, in this study no two-by-two comparisons of the hemostatic agents were carried out [26].

One of the advantages of the study by Oksayan et al was the use of the aging process. Besides, the study compared two different types of hemostatic agents. However, one of these materials was epinephrine, the use of which is associated with specific considerations, and its use might lead to systemic concerns [18]. Of all the studies, the study by Gungor et al was the only study in which TbXT adhesive was not used, and Light Bond was used instead. In that study, the orthodontic button was used instead of orthodontic brackets based on the justification that in the majority of orthodontic treatments of impacted teeth, buttons are used instead of brackets. Also, the study used impacted third molars that had recently been removed were used. The justification was that the impacted third molars, similar to impacted canine teeth, are not present in the oral cavity before the surgical exposure and are not affected by various external factors, such as bacteria, foodstuff, sweets, and abrasive agents that affect the tooth enamel. It is a good idea to choose extracted teeth that were impacted for study but the difference of molar enamel characteristics and canine enamel might change final results. That study, either, did not compare the hemostatic agents [9].

A study by Akendiz et al did not compare different hemostatic agents; However, it compared conventional etch-and-rinse and light-cure primer system and one-step-self-etching primer under contamination with the hemostatic agent. The study said that water could not be used to wash away the hemostatic agent from the tooth surface because the water flow might disrupt the fibrin structure of the surgical area, resulting in hemor-

rhage again. Therefore, the study also evaluated cleaning the hemostatic agent from the tooth surface with moist surgical gauze and drying with an air syringe. However, the comparison did not reveal any significant difference, except when the hemostatic agent was dried with an air syringe, and a self-etching primer system was used [25]. Of all the studies, the study by Karabelkirojlu et al was the only study to evaluate the effect of hemostatic agents concerning orthodontic brackets in vitro and in vivo and make comparisons. The in vitro section of this study simulated the intraoral conditions properly; before contaminating the tooth with a hemostatic agent, the tooth surface was contaminated with blood and dried with an air syringe. Then, contamination was carried out with the hemostatic agent because, under the clinical condition, the surgical exposure results in the contamination of the tooth surface with blood. In addition, in the in vivo section of this study, an aging process was used to simulate the oral environment. This is the only study to mention the time of tooth surface contamination with a hemostatic agent (about two minutes) because it was explained that the hemostatic agent at a longer time (>4 minutes) could remove the entire smear layer from the tooth surface, which might have unfavorable biologic complications. One of the disadvantages of the in vivo section of the study was that it was a split-mouth and single-blind study [17].

The study by Scarano et al was an in vivo study, in which impacted maxillary and mandibular canines and impacted maxillary premolars were used. Since these teeth have different positions, visibility, access, bleeding, and isolation are different in these teeth, which might affect the final outcome. Besides, the articles made no mention of the etching system and its application, the type of adhesive and bracket. Each of these variables might affect the bond and bracket failures [19]. A study by Adiloglu et al is the last study to date to evaluate the effect of hemostatic agents concerning impacted teeth and orthodontic treatment. The study did not evaluate the use or no use of hemostatic agents; it compared ABS and adrenalin as two hemostatic agents. Besides, although it was reported at the end of this in vivo study that there was no bonding failure until the end of the study, the study only aimed to evaluate parameters, such as bonding time and bleeding time during the surgical exposure [28]. The bonding mechanisms in the enamel and dentin involve removing some mineral agents, creating a cavity on the surface, and filling this cavity with resin tags that create a micromechanical tension after setting [30]. It has been reported that if the etched surface becomes wet, the cavities are filled, and the number of resin tags decreases, leading to an overall decrease in bond strength [31]. Akendiz, Karabekirolu, and Oksayan et al [17,18,25] contaminated the surface with hemostatic agents before etching-and-rinsing and bonding procedures to prevent it. On the other hand, such a process is more similar to the clinical and oral cavity condition because in the oral cavity, after the surgical exposure and hemorrhage first, a hemostatic agent is used to stop hemorrhage, followed by the etching and bonding procedures. Therefore, during the use of a hemostatic agent, the tooth surface can become contaminated with this agent. This technique more closely simulates the clinical conditions compared to the study by Trakyali and Gungor et al. [9,26], in which, first, etching and rinsing were carried out, and then the surface was contaminated with the hemostatic agent. However, in the clinic, hemorrhage might occur at any stage, and a hemostatic agent might be used before etching-and-rinsing step or after it. Therefore, evaluating the effect of hemostatic agents on the orthodontic bonding process is relevant before etching, after etching, or after the adhesive applying. Concerning the use of hemostatic agents and their effect on bonding orthodontic brackets, factors such as surface contamination before or after the etching process, the type of the tooth used (human or bovine), the type of the adhesive used, the bracket type, the aging process, and irrigating or not irrigating the hemostatic agent from the tooth surface, affect the results [17]. However, since there were no specific and uniform methods used in studies, comparative analysis of the results was a limitation, and it was not possible to carry out statistical analyses. Besides, due to the paucity of studies in this field, it appears that it is not possible to reach a definite conclusion on the effect of different hemostatic agents on the bonding of orthodontic brackets.

Conclusion

Under the limitations of the present review study, the results showed that using hemostatic agents in disimpaction treatments can increase the bond strength of brackets to tooth surfaces by preventing the contamination of the tooth surface with blood. However, during the use of these agents, care should be exercised not to contaminate the tooth surface with hemostatic agents because it can adversely affect the bond between the bracket and the tooth surface, resulting in a weaker bond. However, in vitro studies have shown that this bond is better than the bond when the tooth surface is contaminated with blood. Despite the conclusion

above, it is evident that due to the differences in the methods between the studies evaluated and the limited number of studies carried out on the subject, further studies are necessary to reach a definitive conclusion.

Conflict of Interest

There is no conflict of interest to declare.

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