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Evaluation of biocompatibility of four different one-step self-etching adhesives by animal experimental method

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ABSTRACT

Aim: The success of materials used in dentistry is closely related to their biological safety. In recent years, there has been growing concern about the biocompatibility of self-etch adhesives, which are frequently used in restorative dental treatment. The aim of this study is to compare the biocompatibility of four different single-stage self-etch adhesive materials (prime & bond one select. optibond all-in-one, clearfil universal bond, and single bond universal) with the animal test method and evaluate them histopathologically.

Methods: The experimental materials were polymerized by filling 10 mm-long, 2 mm-diameter polyurethane tubes. For each adhesive, 21 tubes were used. The tubes were placed in the subcutaneous pockets formed by four different incisions in the backs of 21 adult male albino rats. On the 7th, 30th, and 60th days, rats were randomly divided into three groups. At the end of these durations, the tube and the surrounding 2 cm^2 of tissue were excised together. The sections were taken into preparation and stained with hematoxylen and eosin. The severity of inflammation, inflammatory cell count, and fibrous capsule thickness were evaluated histologically by light microscopy.

Results: On the 7th day of samples, lesions due to acute inflammation, edema, and PMNL infiltration were observed. In the 30th-day samples, it was observed that inflammation decreased against all materials and fibrocollagen tissue increased. On the 60th day, granulation and fibrous tissue increased due to regeneration and reparation processes. On the 60th day, the number of inflammatory cells decreased significantly compared to the 7th day. When the fibrous tissue formation was evaluated, it was found that the 7th day score was significantly lower than the 60th day score.

Conclusion: The severity of the inflammatory reaction at the beginning of all materials can be explained by the effects of residual monomer release and surgical trauma.

Keywords: Self-etch adhesive, biocompatibility, animal testing

INTRODUCTION

Adhesive resins, which have been used frequently in restorative dentistry in recent years, have been the materials on which the most biocompatibility research has been conducted because they contain a number of compounds that may cause different biological reactions.[1] Adhesives bond to composite resin as well as enamel and dentin. While bonding to enamel and dentin is explained by micromechanical adhesion, bonding to composite resin can be explained by co-polymerization of the double bonds in the oxygen inhibition layer. This occurs when the resin monomers and the inorganic structure of the tooth are interlocked during polymerization. Micromechanical bonding is a penetration process.[2]

Nowadays, the reclassification of adhesives based on their clinical application procedures and their interactions with dentin has come to the fore.[2,3] According to this classification, adhesive systems are: Etch&Rinse (Acid Wash) Adhesives. Self-etch (Self Acid) Adhesives and Glass Ionomer-Containing Adhesive Systems.[2,4]

Self-etch adhesives can be two- or one-step according to their stages and can be examined in three groups as strong (pH<1), medium (1≤pH≤2), and weak (pH>2) according to their acidizing properties and pH.[5]

The structure of adhesive systems includes acrylic resin monomers, initiators, inhibitors, solvents, and some fillers. Since each component has a special function, it is important to know them in order to determine the current biological risk potential of adhesives.[6] As a result of inadequate polymerization of adhesive materials, some of the monomers in their content may dissolve in saliva. This is known to cause direct biological reactions in cells and tissues.[7,8] In

addition, residual monomers have been reported to cause a delay in odontogenic differentiation and mineralization processes in root cells and pulpal cells.[7] Dental materials should be evaluated for biological risks before clinical use. Biocompatibility is the ability of a material applied to living tissue to remain compatible without causing any change in the surrounding tissues.[9,10] The tests used to investigate the biocompatibility of dental biomaterials are in vitro (primary) tests, in vivo animal experiments (secondary tests), and usage tests.[9]

The main feature of primary tests is the ability to control the interfaces of the biomaterial and the environment of the cells and to measure the cell response precisely and in detail.[9,11-13] In animal experiments, the material to be tested for biocompatibility is implanted into the tissue to evaluate its local toxic effect.[9,11,13] Through animal experiments, it is possible to predict the potential toxic hazards of dental materials before clinical use.[9,11,12,14] The inflammatory tissue response elicited by the implantation of dental materials into the subcutaneous connective tissue of experimental animals is similar to that of exposed pulp connective tissue. The ability to obtain a biological response similar to human tissues has prevented the use of humans as test subjects. Therefore, the subcutaneous implantation test is considered as the most reliable biocompatibility evaluation method in animal experiments.[15]

The aim of this study was to compare the biocompatibility of four different resin-containing single-stage self-etch adhesive materials [Prime&Bond One Select (PB-OS). Optibond All-in-One (OB-AIO). Clearfil Universal Bond (CUB), and Single Bond Universal (SUB)] by animal experiment method and to evaluate them histopathologically.

METHODS

This study was conducted according to the guidelines of ISO 7405 and ISO 10933-6. Dicle University Prof. Dr. Sabahattin Payzın Health Sciences Research and Application Center Animal Experiments Local Ethics Committee (DÜHADEK) approval (Pro. No: 2017/17) was obtained before the study. Four different single-stage self-etch adhesive materials (**Table 1**) were used in the study.

Table 1. Adhesive materials used in the study and their chemical structures

Product trade name	Code	Manufacturer Company	Lot No.
Prime&bond® one select	PB-OS	Dentsply DeTrey Konstanz, Germany	7110158
Optibond® all-in-one	OB-AIO	Kerr Scafati, Italy	67488448
Clearfil® universal bond	CUB	Kuraray Okayama. Japan	1T0014
3M® Single bond universal	SBU	3M ESPE Neuss, Germany	80411B

In this study, 21 male Wistar albino rats weighing 300-400 g were used. Polyurethane tubes of 10 mm in length and 2 mm in diameter were used to prepare the samples. Polyurethane tubes were disinfected with 96% alcohol before application. For each adhesive, 21 polyurethane tubes were used. Dental adhesives were placed in polyurethane tubes under aseptic conditions and polymerized with a light device for 10 seconds on all surfaces of the tubes.

Before the experiment, all rats were anesthetized by placing them in a cotton wool jar of 15% Ether (Sigma-Aldrich, Germany). Intraperitoneal anesthesia of the experimental animals was achieved under aseptic conditions using 75 mg/kg Ketamine hydrochloride (Ketalar® Pfizer, Turkey) and 5 mg/kg Xylazine hydrochloride (Xylazol® Provet, Turkey). Sedation was maintained with 5% Ether throughout the surgical procedure. The incision sites of the animals whose backs were shaved were disinfected with 10% Povidone iodine skin antiseptic. The rats were placed in the prone position, and 4 different incisions with defined borders were made with the help of a scalpel under aseptic conditions: 2 in the back and 2 in the lumbar region (Figure 1). In the incision sites, subcutaneous pockets of 1 cm depth were formed by blunt dissection using dissection scissors. One polyurethane tube containing a different adhesive material was placed in each subcutaneous pocket under aseptic conditions. The prepared incision lines were closed with resorbable 3.0 sutures (Boz, Turkey) and antisepsis were achieved by wiping the wound sites with povidone iodine.

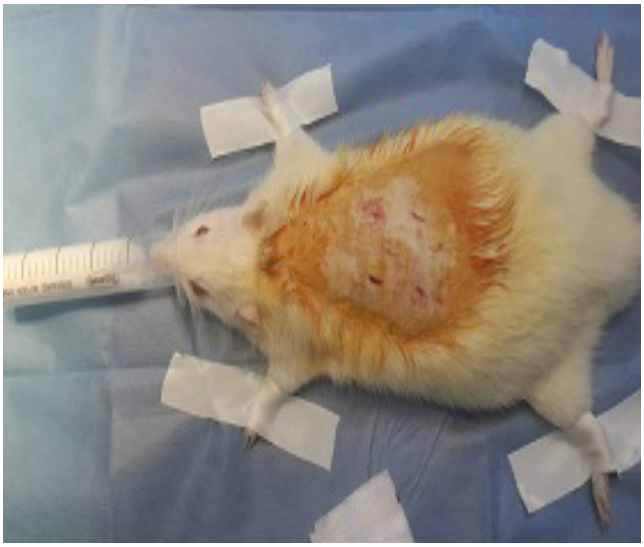


Figure 1. Incision lines on the back and lumbar region of the animals

Twenty-one rats were randomly divided into three equal groups to be examined on days 7, 30, and 60. At the end of the experimental periods, all rats were again anesthetized with ether, and intraperitoneal anesthesia was performed. The dorsal regions of the animals were shaved again, and the area where the samples would be taken was cleaned. Under the cleaned skin, the areas where the implanted samples were located were identified, and the tube and 2 cm^2 of tissue surrounding the tube were cut out together. After the completion of the experimental period, each experimental animal was euthanized by high-dose Thiopental sodium (Pental®İE Ulugay İlaç San, Turkey) anesthesia. Following the experimental periods, the removed specimens were placed in sterile storage containers containing 10% buffered formalin solution and placed in paraffin blocks. Serial 5-µm sections were taken from the prepared paraffin blocks using a microtome and stained with Hematoxylin & Eosin (H&E). Histopathologic examination and evaluation of the sections were performed at Dicle University, Faculty of Veterinary Medicine, Department of Pathology. The preparations were evaluated under a light microscope (Nikon Eclipse E200, Japan) at 40x, 100x, 200x, and 400x magnification and photographed under a light microscope with a digital camera attachment (Nikon Eclipse E400, Japan).

On day 7, samples of the adhesives were evaluated, and lesions due to acute inflammation were observed in the

subcutis and subcutaneous adipose tissue, Edema was seen in the adipose tissue and fibrocollagenous tissue in the periphery of the tube cavity. Extreme hyperemia and severe vasodilation were observed in capillary vessels. There was severe Polymorphonuclear Leukocyte (PMNL) infiltration. There was diffuse leukocyte infiltration consisting mostly of neutrophil granulocytes and lesser amounts of basophils and eosinophils (**Figure 2**).

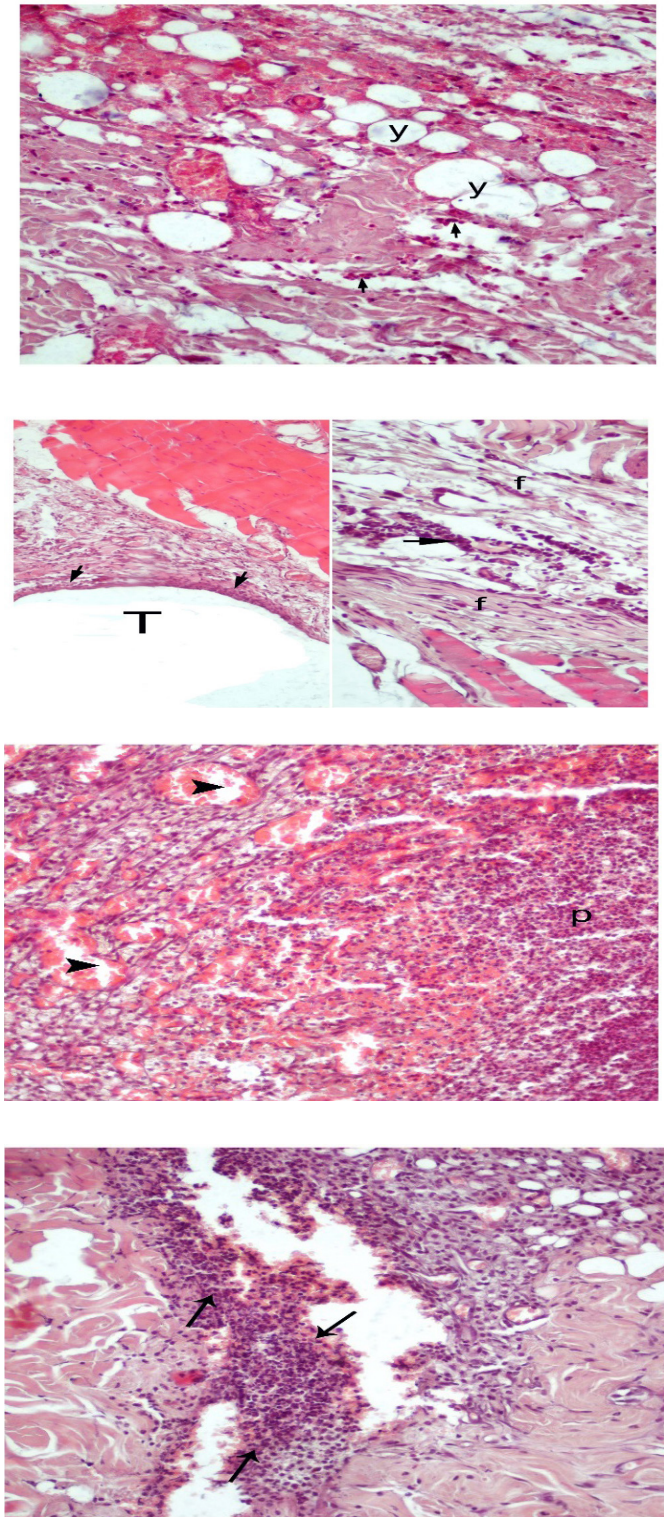


Figure 2. A) PMNL infiltration in day 7 samples of PB-OS (**Arrow;** acute inflammation picture and PMNL infiltration, **Y;** adipose tissue. H&E, 200x magnification). **B)** PMNL infiltration in day 7 samples of OB-AIO material **a:** (**Arrow;** dense PMNL infiltration in the tube mouth, **T;** tube cavity, H&E, 100x magnification). **b:** (**Arrow;** PMNL infiltration, **f;** fibrous tissue, H&E, 200x magnification). **C)** Acute inflammation picture in day 7 samples of CUB material (**Arrow;** vasodilatation due to acute inflammation and severe hyperemia in capillaries, **p;** dense PMNL infiltration, H&E, 200x magnification). **D)** PMNL infiltration in fibrocollagen tissue in day 7 samples of SBU material (**Arrow;** dense PMNL infiltration in fibrocollagen tissue, H&E, 200x magnification).

When the 30th day samples of the adhesives were evaluated, it was observed that the inflammation decreased compared to the 7th day and became subacute; capillary vessel hyperemia and dilatation severity decreased. Vascularization (angio-genesis) was determined due to an increase in fibrocollagen tissue. Diffuse Mononuclear Leukocyte (MNL) infiltration consisting mostly of lymphocytes was observed in fibrocollagen tissue, starting from subcutaneous adipose tissue. Plasma cells, macrophages, and histiocytes, as well as rare PMNLs, were observed (**Figure 3**).

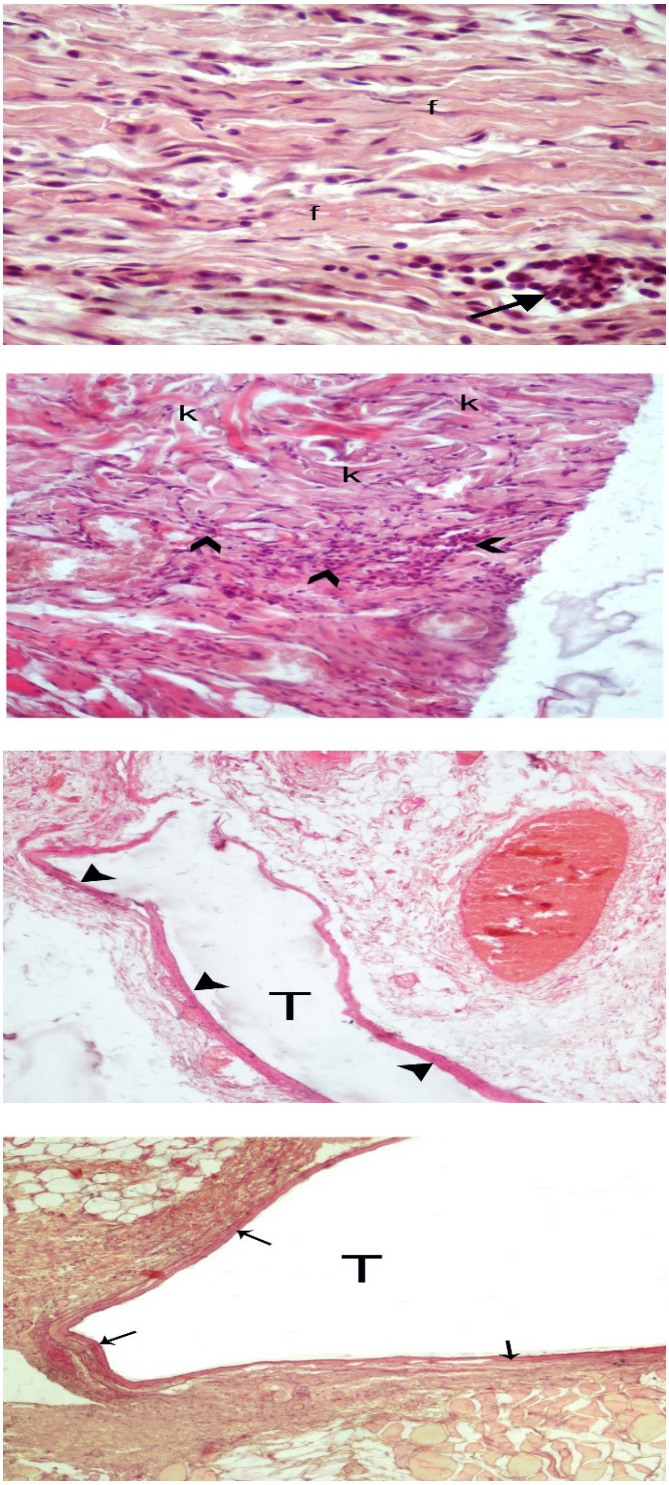


Figure 3. A) Fibrocollagen formation and MNL infiltration in day 30 samples of PB-OS. (**Arrow;** MNL infiltration, **f;** fibrocollagen tissue formation, H&E, 400x magnification). **B)** Fibrocollagen increase and MNL infiltration in day 30 samples of OB-AIO. (**Arrow;** severe MNL infiltration, **k;** increase in fibrocollagen tissue, H&E, 200x magnification). **C)** Fibrocollagen tissue formation in day 30 samples of CUB material. (**Arrow;** lamellar fibrocollagen tissue formation around the tube, **T;** tube cavity, H&E, 100x magnification).
D) Fibrocollagen tissue formation in day 30 samples of SBU material (**Arrow;** severe fibrocollagen tissue formation around the tube in lamellar style, **T;** tube cavity, H&E, 100x magnification)

When the 60th day specimens were evaluated, compared to the 30th day, it was observed that the inflammation decreased and became chronic, and granulation and lamellar fibrous tissue increased due to regeneration and reparation. Very few MNL cells were observed (**Figure 4**).

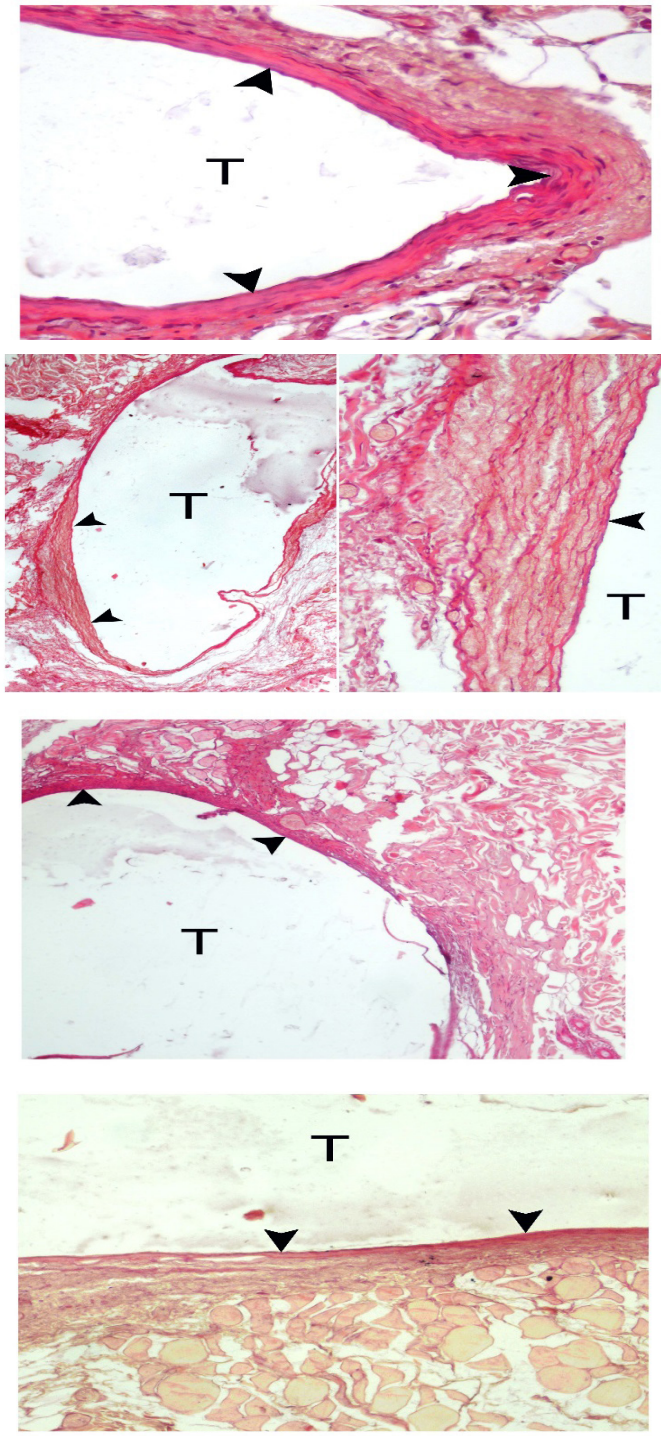


Figure 4: A) Fibrocollagenous tissue formation in day 60 samples of PB-OS. (**Arrow;** dense fibrocollagenous tissue formation around the tube in lamellar fashion, **T;** tube cavity, H&E, 400x magnification. **B)** Severe fibrocollagen formation in day 60 samples of OB-AIO. a: (**Arrow;** severe fibrocollagen tissue formation around the tube in lamellar style, **T;** tube cavity, H&E, 40x magnification) **b:** (**Arrow;** granulation tissue, **T;** tube cavity, H&E, 400x magnification). **C)** Fibrocollagen tissue formation in day 60 specimens of CUB material. (**Arrow;** severe fibrocollagen tissue formation around the tube in lamellar fashion, **T;** tube cavity, H&E, 100x magnification). **D)** Fibrocollagen tissue formation in day 60 samples of SBU material. (**Arrow;** severe fibrocollagen tissue formation around the tube in lamellar fashion, **T;** tube cavity, H&E, 100x magnification).

Statistical Analysis

The SPSS 21.0 computer software program was used for statistical analysis of the results. The findings were shown as "mean ± standard deviation" and conformity to the normal distribution was determined by the Shapiro-Wilk test. Kruskal Wallis-H test was used to analyze the differences between the groups. In cases of significant differences, Post-Hoc multiple comparison test was used to determine the groups with differences. Friedman's Two-Way ANOVA test was used to analyze more than two dependent variables. In cases of significant differences, multiple comparison tests were used. $p<0.05$ was considered statistically significant.

RESULTS

Inflammatory cells around the tube cavity were evaluated under a light microscope in five different fields at 400x magnification. When the 7th day inflammatory cell counts were evaluated, a statistically significant difference was found between the groups ($p<0.05$). The highest cell count was observed in the PB-OS material, while the lowest value was observed in CUB material. In the pairwise comparison of the values between the groups, it was determined that the cell count of the SBU material was significantly lower than that of PB-OS material (**Table 2**).

When the 30th-day inflammatory cell counts were evaluated, a statistically significant difference was found between the groups ($p<0.05$). The highest cell count was observed in the PB-OS material, while the lowest value was observed in OB-AIO material. In the pairwise comparison of the values between the groups, it was determined that the cell counts of OB-AIO and CUB material were significantly lower than the PB-OS material (**Table 3**).

When the 60th-day inflammatory cell counts were evaluated, a statistically significant difference was found between the groups ($p<0.05$). The highest cell count was observed in the PB-OS material, while the lowest value was observed in CUB material. In the pairwise comparison of the values between the groups, it was determined that the cell number of CUB material was significantly lower than that of the PB-OS material (**Table 4**).

Inflammation (PMNL and MNL) and fibrous tissue formation scoring were performed to determine the reaction in the subcutaneous tissue of the rats.

Inflammation scoring criteria were determined as follows: Grade 0 (no reaction); no PMNL and MNL cell infiltration; Grade 1 (mild reaction); PMNL and MNL infiltration involving <20% of all biopsies in Grade 2 (moderate reaction); PMNL and MNL infiltration involving 20-40% of all biopsies in Grade 3 (severe reaction); PMNL and MNL infiltration involving >40% of all biopsies.

The scoring criteria for fibrous tissue formation were determined as follows: Grade 0 (no reaction); normal fibrous tissue morphology; Grade 1 (mild reaction); mild fibrous tissue formation; Grade 2 (moderate reaction); moderate fibrous tissue formation; Grade 3 (severe reaction); severe fibrous tissue formation.

Inflammation and fibrous tissue formation around the tube cavity were evaluated and scored under light microscopy at 40x and 100x magnifications.

Table 2. Difference between day 7 inflammatory cell counts of four different adhesive materials

n		GROUP				Kruskal-Wallis H Test	
		Lowest	Highest	Mean	p	Pairwise comparison	
Inflammatory cell count Day 7	PB-OS (Mean ± SD)	7	168.2	187	180.54±6.09	0.007	SBU/PB-OS
	OB-AIO (Mean ± SD)	7	156.8	178.2	171.09±8.79		
	CUB (Mean ± SD)	7	113.6	183	156.6±26.37		
	SBU (Mean ± SD)	7	138.4	169	157.63±9.75		
	Total	28	113.6	187	166.46±17.42		

Table 3. The difference between the 30th day inflammatory cell counts of four different adhesive materials

n		GROUP				Kruskal-Wallis H Test	
		Lowest	Highest	Mean	p	Pairwise comparison	
Inflammatory cell count Day 30	PB-OS (Mean ± SD)	7	65.2	88.2	72.46±8.19	0.001	OB-AIO/ PB-OS CUB/PB-OS
	OB-AIO (Mean ± SD)	7	40.4	52.2	47.29±4.02		
	CUB (Mean ± SD)	7	44.4	52	48.91±2.42		
	SBU (Mean ± SD)	7	53.6	64.6	57.91±3.82		
	Total	28	40.4	88.2	56.64±11.25		

Table 4. The difference between the inflammatory cell counts of four different adhesive materials at day 60

n		GROUP				Kruskal-Wallis H Test	
		Lowest	Highest	Mean	p	Pairwise comparison	
Inflammatory cell count Day 60	PB-OS (Mean ± SD)	7	7.6	9.2	8.46±0.56	0.002	CUB/PB-OS
	OB-AIO (Mean ± SD)	7	6.8	8.8	7.91±0.75		
	CUB (Mean ± SD)	7	5.8	7.6	6.8±0.57		
	SBU (Mean ± SD)	7	6.6	7.8	7.26±0.5		
	Total	28	5.8	9.2	7.61±0.86		

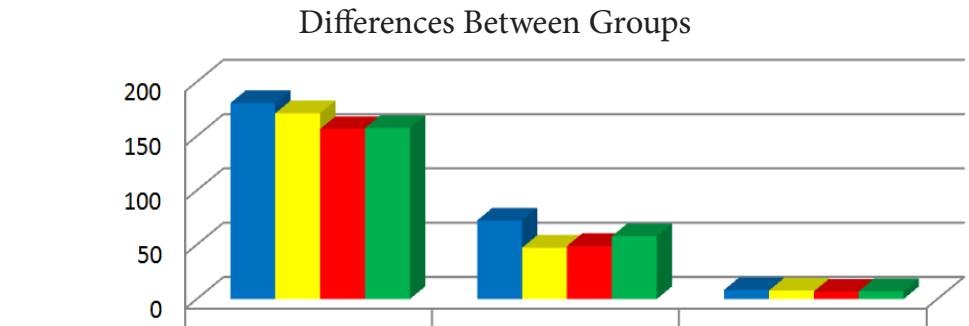
When the scores of inflammations and fibrous tissue formation were evaluated, no statistically significant difference was observed between the experimental materials ($p>0.05$).

When the inflammation scores of the experimental materials at different time periods were evaluated (**Table 7**. Figure 4), it was determined that the 60th day inflammation score of all materials was significantly lower than the 7th day score ($p<0.05$).

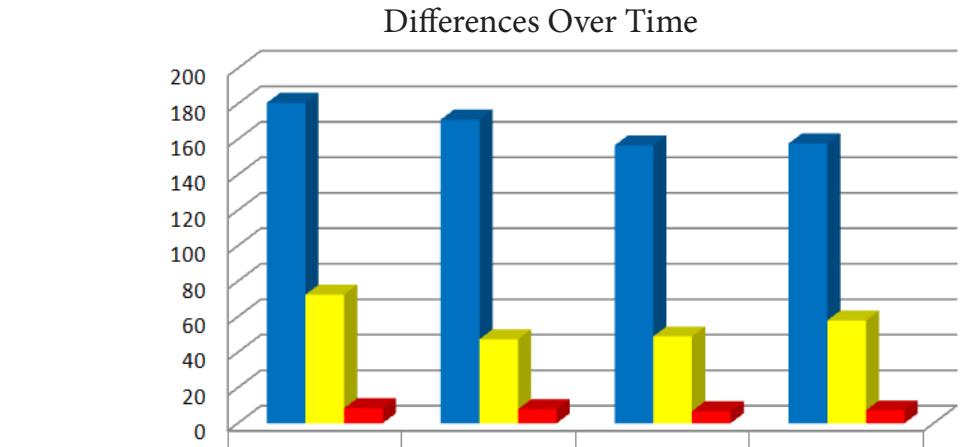
When the fibrous tissue formation scores of the experimental materials at different time periods were evaluated (**Table 7**, **Figure 4)**, it was determined that the 7th day fibrous tissue formation score of PB-OS, OB-AIO, and SBU materials was significantly lower than the 60th day score ($p<0.05$).

When the fibrous tissue formation scores of the CUB material at different time periods were evaluated (**Table 7**. **Figure 4**), it was determined that the fibrous tissue formation score of this material on the 7th day was significantly lower than the 30th and 60th day scores ($p<0.05$).

Table 5. Differences between groups and differences over time



	Day 7 cell count	Day 30 cell count	Day 60 cell count
PB-OS adeziv	180,54	72,46	8,46
OB-AIO adeziv	171,09	47,29	7,91
CUB adeziv	156,6	48,91	6,8
SBU adeziv	157,63	57,91	7,26



	PB-OS adeziv	OB-AIO adeziv	CUB adeziv	SBU adeziv
Day 7 cell count	180,54	171,09	156,6	157,63
Day 30 cell count	72,46	47,29	48,91	57,91
Day 60 cell count	8,46	7,91	6,8	7,26

Table 6. Scoring of inflammation and fibrous tissue formation in four different adhesive materials at different time periods

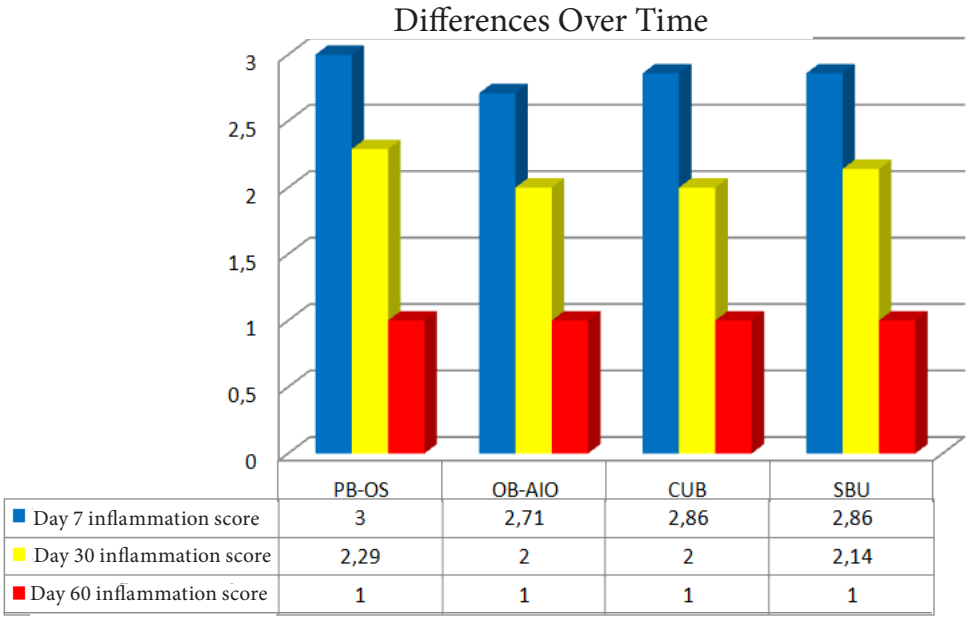
	Day	N	PB-OS				OB-AIO				CUB				SBU			
			G0	G1	G2	G3	G0	G1	G2	G3	G0	G1	G2	G3	G0	G1	G2	G3
Inflammation	7	7	0	0	0	7	0	0	2	5	0	0	1	6	0	0	1	6
	30	7	0	0	5	2	0	0	7	0	0	0	7	0	0	0	6	1
	60	7	0	7	0	0	0	7	0	0	0	7	0	0	0	7	0	0
	7	7	6	1	0	0	7	0	0	0	6	1	0	0	7	0	0	0
Fibrous tissue formation	30	7	0	0	6	1	0	0	5	2	0	0	3	4	0	0	6	1
	60	7	0	0	1	6	0	0	1	6	0	0	1	6	0	0	1	6

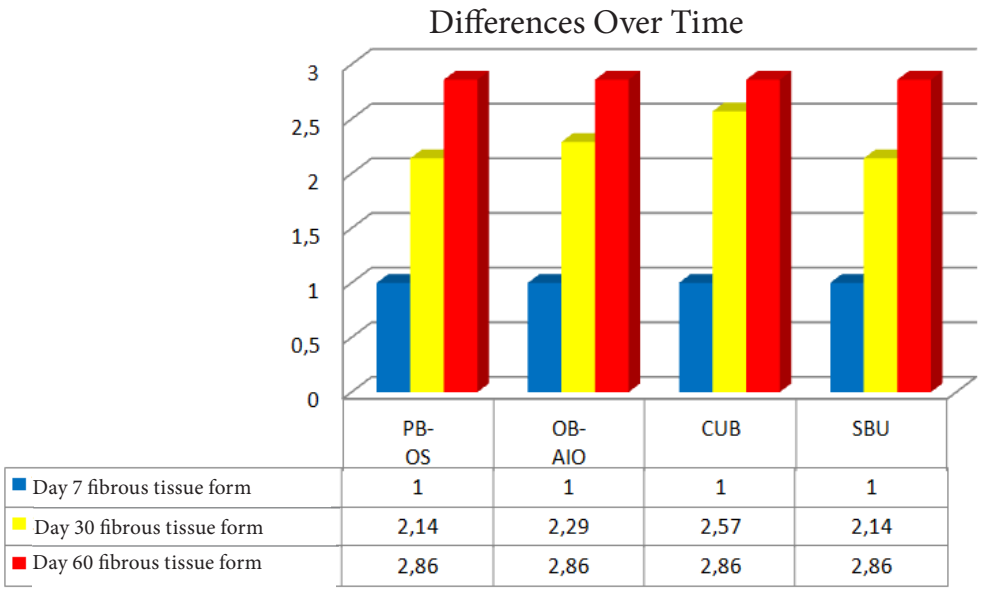
Table 7. Findings of inflammation and fibrous tissue formation scores of the materials for different time periods

Friedman's Two-Way Anova Test	Day	PB-OS	Day	OB-AIO	Day	CUB	Day	SBU
Inflammation	7a	0.002	7a	0.002	7a	0.001	7a	0.002
	30		30		30		30	
	60		60		60		60	
Fibrous tissue formation	7a	0.002	7a	0.003	7a	0.006	7a	0.002
	30		30		30b	0.033	30	
	60		60		60		60	

a: Statistical difference between day 7th and 60th p values.
b: Statistical difference between 7th and 30th day p values)

Table 8. Differences between times in terms of inflammation and fibrous tissue formation





DISCUSSION

The most commonly used resin-containing aesthetic materials in restorative dental treatment is composite resins (16). Resin-containing materials contain various monomers (such as Bis-GMA and UDMA, HEMA and TEGDMA) in different concentrations.[17] It has been reported that the application of resin-containing dental materials in direct contact with the pulp tissue causes pulp inflammation.[18] In the first 24-48 hours following the polymerization of the monomers, the rate of cytotoxicity is at its highest level.[19] This reveals the importance of the remaining dentin thickness

(20). In a study. 34 different components were released from four different resin-containing composite materials.[21]

Today, many materials are offered for clinical use without concern about their biocompatibility.[20] The effects of dental materials on teeth and surrounding tissues, their safety, and their biocompatibility should be investigated before clinical use.[22,23]

In studies, it is mentioned that these components released from adhesive materials into the oral environment cause a number of local and systemic side effects or allergic reactions.[14,24] High doses of TEGDMA, UDMA, Bis-GMA, and Bisphenol-A (BPA) have been found to cause immunosuppression.[25] It is claimed that monomers released from resin materials are tumor initiation risk factors for human salivary glands and also show toxicity in renal cells.[26,27] Al-Hiyasat et al.[28] emphasized a 54.5% decrease in fertility in a study evaluating the effect of BPA on female mouse fertility.

While low concentrations of Bis-GMA induce apoptosis, high concentrations increase cell death with necrosis. Especially after cervical restorations, prolonged contact of Bis-GMA with gingival tissues may cause lichenoid reactions or irritations in the oral mucosa.[29]

In a study by Nowicka et al.[30], the response of the pulp-dentin complex was analyzed after direct pulp capping treatment using self-etch adhesive systems. In most of the specimens, pulpal reaction and lack of dentin bridge formation occurred with tissue disruption. In the teeth in which calcium hydroxide was used, a mild inflammatory response in the pulp with tissue disruption and a high rate of reparative dentin formation were observed. This study is similar to the studies of Koliniotou-Koumpia and Tziafas.[31] and da Silva et al.[32] on dogs.

In an in-vitro study, Süsgün Yıldırım et al.[6] compared the cytotoxicity of five different self-etch adhesives [Prime&Bond One Select (PB-OS), Optibond All-in-One (OB-AIO), G-bond (GB), Clearfil Universal Bond (CUB), Single Bond Universal (SBU)] in cell culture medium. In the SBU, CUB, GB, and OB-AIO groups, zone formation exceeding 1cm around or under the test material was detected. In the PB-OS group, the zone boundaries were close to 1cm. When the effects of the materials incubated at three different time periods on cell proliferation were evaluated; CUB was found to be the most cytotoxic material at the end of the 24-hour incubation period, GB and SBU at the end of the 48-hour incubation period, and OB-AIO at the end of the 72-hour incubation period. It was stated that the cytotoxic effect of all adhesives increased dose-dependently and changed over time.

It is widely believed that these and similar in-vitro studies cannot fully reflect the interactions in living organisms. Indeed, in our study, contrary to these results, we found that PB-OS adhesive material was less biocompatible compared to other adhesives.

In a study by Costa et al.[33] that evaluated the biocompatibility of Clearfill Liner Bond 2, Single Bond, and calcium hydroxide in rats, they used 7, 30, and 60-day periods.[15] evaluated the biocompatibility of three different adhesive materials at 7, 115, and 30-day intervals in a study in rats.[34] used time periods of 15, 30, and 60 days in their similar study on rats. In our study, considering the time-dependent change in the amount of monomer released from the samples, three different time periods (7, 30, and 60 days) were examined and histopathologically evaluated.

In a study by Moysés et al.[15] that evaluated the biocompatibility of three different adhesive materials in rat subcutaneous connective tissue, acute and severe inflammatory responses were detected in all materials except the control group at the end of the 7-day period. On the 15th day, more severe inflammation was observed in Prime&Bond 2.1 and Prime&Bond NT materials compared to Scotchbond MP Primer, and it was determined that the inflammatory process continued on the 30th day. It was concluded that the Scotchbond MP Primer group was more biocompatible than the other two groups.

Costa et al.[33] evaluated the biocompatibility of two different adhesive materials (Clearfil liner bond 2, Single bond) and calcium hydroxide in rat subcutaneous tissues and found an inflammatory response in both adhesive resins at day 7, fibrous capsules at day 30, and connective tissue healing as well as an inflammatory reaction at day 60.

In a similar study, Teixeira et al.[35] evaluated the biocompatibility of three different adhesive materials (Prime&Bond NT, Bond1, and Optibond Solo) with calcium hydroxide and found that intense inflammation was observed at day 15, while a persistent inflammatory reaction persisted at day 60.

Machado et al.[36] examined the biocompatibility of Single Bond, Clearfil SE Bond, and Prime&Bond NT dental adhesives; it was suggested that Prime&Bond NT adhesive material showed less biocompatibility compared to the other two adhesives.

In our study, in which we evaluated the biocompatibility of single-stage self-etch adhesive materials (Prime&bond One Select, Optibond All-in-One, Clearfil Universal Bond, Single Bond Universal), no abscess formation or necrosis was observed in any of the specimens. On day 7, lesions and edema due to acute inflammation were observed against PB-OS and CUB materials. However, there was diffuse PMNL infiltration. Against OB-AIO and SBU materials, PMNL infiltration accompanied by advanced edema was observed in some areas. In the 30th day samples, it was observed that inflammation against all materials decreased, became subacute, and fibrocollagen tissue increased. MNL infiltration, consisting mostly of lymphocytes, was observed. From day 7 onwards, we think that the reason for the rapid decrease in the inflammatory reaction is due to the release of residual monomers and the gradual decrease in the effect of surgical trauma. In the 60th-day specimens, it was observed that the severity of inflammation against all materials decreased further, and granulation and lamellar fibrous tissue increased due to regeneration and reparation processes.

In our study, we determined that the PB-OS adhesive material was less biocompatible compared to the other adhesives. When inflammatory cell counts were evaluated in the 7th and 60th day samples, the highest cell count was observed in the PB-OS material, while the lowest value was observed in CUB material. When the 30th-day inflammatory cell counts were evaluated, the highest cell count was again observed in the PB-OS material, while the lowest value was observed in the OB-AIO material. The number of inflammatory cells in all materials at day 60 significantly decreased compared to day 7. When fibrous tissue formation was evaluated, it was determined that the 7th day score was significantly lower than the 60th day score.

CONCLUSION

In our study, PB-OS adhesive material was found to be less biocompatible than the other adhesives in all groups regardless of time, and at the same time, tissue reaction was controlled over time in all materials. However, biological differences between experimental animals and humans should be taken into consideration when evaluating the results of in vivo studies.

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ETHICAL DECLARATIONS

Ethics Committee Approval: Dicle University Prof. Dr. Sabahattin Payzın Health Sciences Research and Application Center Animal Experiments Local Ethics Committee (DÜHADEK) approval (Pro. No: 2017/17) was obtained before the study.

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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