

# The effects of argon laser curing of a resin adhesive on bracket retention and enamel decalcification: a prospective clinical trial

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**SUMMARY** A prospective clinical trial was carried out to compare argon laser-curing of a traditional light-activated composite resin with conventional visible light-curing in terms of bond failure rate and incidence of enamel decalcification. Forty-five patients with a total of 742 metal brackets bonded to the upper and/or lower teeth in a modified split-mouth design participated in the study. The adhesive (Transbond XT) on the control teeth was cured by conventional visible light for 40 seconds, and the experimental teeth were exposed to 10 seconds of 250 mW argon laser irradiation. The patients were monitored for a period of 14 months. Intraoral photographic slides of the maxillary anterior teeth (212 in total) were taken at the beginning of treatment, after 12 months of treatment, following application of a plaque disclosing agent, and at the end of the observation period, following temporary debonding. Seven dentists used standardized rating systems to evaluate decalcification and plaque accumulation.

The results of this study indicated that there were no significant differences between curing methods for the incidence of decalcification and plaque accumulation. However, the 10 second argon laser-curing method showed a statistically lower bond failure rate (2.4 per cent,  $P < 0.05$ ) than the 40 second conventional visible light-curing method (5.7 per cent).

It is concluded that the use of argon laser curing is superior to that of conventional light-curing with respect to bond failure and chairside time. However, the incidence of decalcification seems to be similar.

## Introduction

Light-cured resin adhesives have become widely used in orthodontics (Keim *et al.*, 2002). As opposed to chemically-cured bonding systems, these adhesives allow for accurate bracket positioning without time limitation (Sonis, 1988). However, a major disadvantage is the 20–40 seconds of light-curing required to set the composite for each bracket. Recent advances in laser technology have led to the application of argon laser light for rapid photopolymerization of resin composites.

Argon laser light differs significantly from that produced by conventional tungsten-quartz halogen curing units. Camphorquinone, the photoinitiator in most photoactivated dental resins (American Dental Association, 1985), is highly sensitive to light in the blue region of the visible light spectrum and reaches peak absorption at approximately 480 nm (Cook, 1982). Conventional light-curing units emit energy over a broad range of wavelengths (400–520 nm) in the blue-green spectrum (Cook, 1982; Yearn, 1985), thereby lacking specificity and thus efficiency. In contrast, the argon laser produces light over a narrow band of wavelengths, around 480 nm (457.9–514.5 nm), making it ideally suited to polymerize composite resins (Talbot *et al.*, 2000). In addition, the argon laser beam is collimated, focused on a specific target, resulting in a more consistent power density over distance (Kelsey *et al.*, 1989; Blankenau *et al.*, 1991). The power density of light

reaching composite from a conventional visible light-curing unit decreases dramatically with distance (40 per cent at 6 mm), due to the divergence of the light (Rueggeberg and Jordan, 1993). Laser light is also coherent, meaning that photons travel in phase and do not collide as they do in conventional light-curing units (Fleming and Maillet, 1999).

Previous *in vitro* studies have shown that argon laser curing of resin adhesives for bracket bonding results in equal bond strength, while needing a quarter of the curing time required by conventional visible light-curing units (Kupiec *et al.*, 1997; Weinberger *et al.*, 1997; Talbot *et al.*, 2000; Lalani *et al.*, 2000). However, clinical investigations are still needed to confirm these results.

Several *in vitro* studies have investigated the preventive effect of low power argon laser irradiation on enamel and found a significant reduction in demineralization area and/or depth following an acidic challenge (Powell *et al.*, 1992; Hicks *et al.*, 1993; Yu *et al.*, 1993; Flaitz *et al.*, 1995; Hicks *et al.*, 1995). The mechanism of action is not entirely clear, but is presumably related to the microsieve network that is created on the enamel surface, which is held responsible for trapping and precipitating dissolved minerals (Oho and Morioka, 1990; Westerman *et al.*, 1996). A clinical pilot study conducted by Blankenau *et al.* (1999), using modified bands for plaque accumulation, found that teeth irradiated by argon laser (12 J/cm<sup>2</sup>, 10 seconds)

showed a 29.1 per cent reduction in average lesion depth when compared with control teeth. Anderson *et al.* (2002) used a similar model for plaque accumulation, and found a 94.1 per cent reduction in lesion depth and a 94.4 per cent reduction in lesion area for teeth irradiated by argon laser (100 J/cm<sup>2</sup>, 60 seconds) when compared with a control group. Pumicing and etching before laser irradiation did not appear to reduce the effect of argon laser irradiation on enamel solubility.

The aim of the present study was to compare argon laser-curing of a light-activated resin adhesive (Transbond XT, 3M Unitek, Monrovia, California, USA) with conventional light-curing in terms of bracket bond failure and enamel decalcification during orthodontic treatment *in vivo*.

### Subjects and methods

Forty-five consecutive adolescent patients (17 boys, 28 girls) who required upper, lower, or both upper and lower fixed appliance therapy with or without extractions were included in the study. All were treated by the same operator, at the Dental Clinic of the Vrije Universiteit Brussels or at a private practice in Sint-Lievens-Houtem, Belgium. The mean age at the start of treatment was 12 years 11 months (range 10 years, 7 months to 18 years, 0 months). Local research ethics committee approval was granted and informed consent was obtained from the subjects before inclusion in the study.

Only contralateral pairs of fully erupted teeth without restorations were included in the investigation. The patients served as their own controls. Using the universal tooth numbering system (1–32), the teeth (742 in total) were divided into two groups, one identified by even numbers and the other by odd numbers. For each patient, the even numbered teeth (incisors, canines and premolars) were bonded using conventional light-curing [Curing Light XL3000, 3M Dental Products, St. Paul, Minnesota, USA; peak power in the 420–500 nm wavelength band (manufacturer)] and odd numbered teeth were subjected to argon laser-curing [Flexilas Argon Laser, A.R.C. Laser GmbH, Eckental, Germany; strong emission lines: 488 and 514.5 nm (manufacturer)]. Aluminium shielding appliances were used to avoid laser irradiation of the control teeth, as suggested by Hsu *et al.* (1998).

### Shielding appliance

Before treatment, alginate impressions were taken and plaster models fabricated. The thermoformed shielding appliances consisting of two plastic sheets (Essix type A, 0.030 inch thickness, clear, Essix-Raintree Corp., Matairie, Louisiana, USA) with a layer of aluminium foil (16 µm thickness, Reynolds, FHP Vileda S.C.S.,

Verviers, Belgium) glued (cyanoacrylate) between them, were then fabricated separately for the upper and/or lower arch (Figure 1). In advance, block-out resin (Ultradent Products Inc., South Jordan, Utah, USA) was applied selectively on to the model to leave the necessary space for bracket placement on the control teeth. The appliance was trimmed to cover only the control teeth.

Prior to the clinical part of this study, *in vitro* testing of the efficacy of the aluminium foil/plastic sheet shielding appliance for the prevention of argon laser beam transmission was performed with a laser energy meter: a thermopile surface absorbing head (Ophir, type FL250A-SH-V1, Danvers, Massachusetts, USA) connected to an energy measuring unit (Nova, Ophir Optronics Ltd, Peabody, Massachusetts, USA). The shielding appliance was tested for transmission when irradiated with a 10 second argon laser beam at a distance of approximately 2 mm, using different power settings (250, 500, 750, and 1000 mW). No transmission ( $0.00 \pm 0.01$  mW) was detected, even at the 1000 mW level.

### Bonding procedure and oral hygiene instructions

Prior to bracket bonding, the output of both curing units was checked/calibrated for every patient using the built-in sensor. All teeth were isolated with cheek retractors, pumiced with a slurry of fluoride-free pumice (Reliance Orthodontic Products, Itasca, Illinois, USA) and water in a slow-speed handpiece with a nylon brush, etched for 30 seconds with a 37 per cent phosphoric acid gel, rinsed for 20 seconds, and dried with compressed air. Transbond XT primer was painted on to the etched surface of the control teeth and thinned with a gentle stream of compressed air. Pre-adjusted edgewise stainless steel brackets (OmniArch, GAC International Inc., Islandia, New York, USA) were then bonded to the control teeth with a traditional composite resin



**Figure 1** The shielding appliance used to avoid argon laser exposure of the control teeth.

(Transbond XT) using conventional light curing. After bracket placement, excess composite material was removed from around the bracket with a sharp probe. The composite resin was then cured for 20 seconds from the incisal and 20 seconds from the gingival, with the light tip at a distance of approximately 2 mm from the bracket. Then, the thermoformed plastic/aluminium foil appliance was placed, and extra pieces of aluminium foil were added interdentally. The experimental teeth were then primed and bonded using the same procedure as above. However, the composite was cured with the argon laser at 250 mW (continuous mode) for 5 seconds from the incisal and 5 seconds from the gingival while maintaining a spot size of approximately 5 mm, resulting in an energy density of 12 J/cm<sup>2</sup>. While curing with the argon laser, a thermoformed plastic/aluminium foil appliance was used to cover the control teeth of the opposing arch. Special eye protection glasses were also worn by the operator and the patient in order to avoid retina damage. Initial aligning archwires (0.014 inch superelastic nickel titanium wires, Sentalloy, GAC International Inc.) were tied into the bracket slots immediately following completion of bracket bonding. The patients were given standardized oral hygiene instructions, including the use of a fluoride-containing toothpaste. Additional fluoride rinsing was not advised.

#### *Bond failure rate*

The patients were monitored for a period of 14 months. They were specifically asked to return if a bracket became loose or if they had any other problem with the appliance. Review appointments were scheduled at 4–5 week intervals. Only first-time failures were evaluated.

#### *Incidence of decalcification*

Maxillary anterior teeth (212 in total) were evaluated for the incidence of decalcification. After pumicing and rinsing, each tooth was photographed pre-operatively at a magnification of 1:1 with a Nikon 6006 35 mm camera with a Lester Dine 105 mm macrolens and Fujichrome Sensia 100 slide film. A predetermined aperture setting with a standardized intraoral photography ring flash was used. All photographs were taken perpendicular to the tooth surface, to provide accurate assessment of possible decalcification. Along with the tooth, a strip of millimetre paper just below or above the tooth was photographed. In cases of where bond failure had occurred, the tooth was not considered in calculating the incidence of decalcification because the act of replacing the bracket could affect the incidence of decalcification. At the end of the 14 month study period, the maxillary anterior teeth were debonded using pliers. The remaining composite was removed with a slow-speed handpiece and a fluted tungsten carbide composite bur. The teeth

were then pumiced, rinsed and photographed using the same procedure and identical camera as previously. Slides taken before and after treatment were simultaneously projected ( $\times 20$  magnification) and a comparison was made by a team of seven dentists. The examiners were unaware which curing unit had been used to bond the teeth. They used a standardized rating system (Gillgrass *et al.*, 2001) to determine the absence or degree of decalcification on the labial surface of each of the maxillary anterior teeth, both pre- and post-treatment: 0, no white area; 1, slight white area; 2, obvious white area or discolouration; 3, frank cavitation.

Each tooth was assigned the median of the ranks given by the seven evaluators. Using the median ranks before and after treatment, decalcification was classified as having worsened (or not) after treatment. To assess the reproducibility of the method, the scoring of 20 patients was repeated 2 weeks later and the decalcification increase (yes/no) assessment was statistically compared using the agreement percentage and kappa ( $\kappa$ ) statistic. According to Altman (1991), the strength of agreement can be interpreted as poor ( $\kappa < 0.20$ ), fair ( $\kappa = 0.21–0.40$ ), moderate ( $\kappa = 0.41–0.60$ ), good ( $\kappa = 0.61–0.80$ ) or very good ( $\kappa = 0.81–1.00$ ). In the present study,  $\kappa$  was found to be 0.717 and the percentage of agreement was 86.4 per cent. Reproducibility was concluded to be good.

#### *Plaque accumulation*

Although argon laser irradiation was not expected to have an effect on plaque accumulation and comparisons were made within individuals, a plaque index was recorded after 12 months of treatment to determine the oral hygiene level and plaque distribution. Plaque was revealed by applying an erythrosine/patent blue disclosing solution (Rondells Blue pellets, SDI Svenska, Dental Instrument AB, Upplands, Väsby, Sweden). After a short rinse, the six maxillary anterior teeth were photographed using the same procedure (including the millimetre paper strip) and identical camera as that for the enamel decalcification assessment. Plaque was also evaluated by the same examiners, using the plaque index around brackets (Trimpeeneers *et al.*, 1997), which is based on the following criteria: 0, no plaque; 1, islands of plaque; 2, continuous line less than 1 mm wide; 3, continuous line greater than 1 mm wide.

The slides of 20 patients were projected once more 2 weeks after initial scoring to assess the reproducibility of the method. The percentage of agreement for the median plaque score was 76.0 per cent and  $\kappa$  was 0.561. Reproducibility was concluded to be moderate.

#### *Statistical analysis*

Following the study design, bond failure occurrence was compared in paired contralateral teeth, and decalcification

increase in paired contralateral teeth and paired adjacent teeth using McNemar's test. The increase in decalcification was assessed in order to acknowledge possible decalcifications before treatment. Decalcification percentages increase were also compared by tooth type, regardless of the curing method, by pairing teeth that were bonded using identical curing methods (Cochran test followed by McNemar's test). Plaque scores were compared in contralateral and adjacent pairs using the Wilcoxon signed rank test. All statistical analyses were performed using SPSS for Windows 11.0 (SPSS Inc., Chicago, Illinois, USA). Significance was established at the  $P < 0.05$  level.

## Results

### *Bond failure rate*

From a total of 371 brackets bonded using the argon laser, nine failed, resulting in an overall failure rate of 2.4 per cent. An equal number of brackets were bonded using conventional visible light curing: 21 bond failures were recorded, an overall failure rate of 5.7 per cent. The difference was statistically significant at the 5 per cent level ( $P = 0.038$ ).

### *Incidence of decalcification*

Of the 106 maxillary anterior teeth bonded using the conventional visible light-curing method, 58 teeth (54.7 per cent) exhibited more decalcification at the end of the investigation. Sixty-two of the 106 teeth (58.5 per cent) bonded with the argon laser-curing method

exhibited more decalcification at the end of the study. The overall decalcification increase rate, regardless of the curing method used, was 56.6 per cent.

Statistical comparisons between methods were carried out by pairing teeth into contralateral (Table 1) and adjacent (Table 2) pairs. Contralateral comparisons were of the opposite teeth (e.g. right and left maxillary central incisors), each receiving a different method. Adjacent comparisons (e.g. left maxillary canine and left maxillary lateral incisor) allowed a regional assessment in the same manner. Only the difference between the left central and left lateral incisors was statistically significant ( $P < 0.05$ ). The left central incisor, bonded using argon laser curing, exhibited a significantly lower decalcification percentage increase (40.5 per cent) when compared with the left lateral incisor (64.9 per cent), bonded using conventional visible light curing.

The decalcification increase was also compared by tooth type, by pairing teeth bonded using identical curing methods. The central incisors were found to have a significantly lower decalcification percentage increase (50.0 per cent) when compared with the lateral incisors (66.2 per cent) ( $P = 0.022$ ). The differences between the central incisors (50.0 per cent) and canines (61.7 per cent) and between the lateral incisors (66.2 per cent) and canines (61.7 per cent) were not statistically significant ( $P > 0.05$ ).

### *Plaque accumulation*

The overall mean plaque score for the maxillary anterior teeth was 2.37 [standard deviation (SD) = 0.83]. The mean plaque scores for teeth irradiated by argon laser

**Table 1** Comparison of decalcification rates for contralateral teeth.

	Sample size		% unchanged		% with decalcification		<i>P</i> value
	Argon laser	Conventional light	Argon laser	Conventional light	Argon laser	Conventional light	
Canines	30	30	36.7	40.0	63.3	60.0	1.000
Lateral incisors	37	37	29.7	37.8	70.3	62.2	0.549
Central incisors	39	39	56.4	43.6	43.6	56.4	0.267

**Table 2** Comparison of decalcification rates for adjacent teeth.

	Sample size		% unchanged		% with decalcification		<i>P</i> value
	Argon laser	Conventional light	Argon laser	Conventional light	Argon laser	Conventional light	
Right canine/lateral	28	28	28.6	42.9	71.4	57.1	0.344
Right central/lateral	37	37	29.7	45.9	70.3	54.1	0.070
Left lateral/central	37	37	59.5	35.1	40.5	64.9	0.035
Left lateral/canine	28	28	32.4	37.8	67.6	62.2	0.804

and conventional visible light were 2.39 (SD = 0.81) and 2.34 (SD = 0.86), respectively.

Statistical comparisons of the plaque scores of the maxillary anterior teeth for both curing methods were carried out between contralateral (Table 3) and adjacent (Table 4) teeth. The plaque scores of the right central incisors (mean 2.05), irradiated by conventional visible light, were significantly lower ( $P < 0.001$ ) than those for the right lateral incisors (mean 2.65), irradiated by argon laser. The plaque scores of the left central incisors (mean 2.00), irradiated by argon laser, were significantly lower ( $P < 0.005$ ) than those for the left lateral incisors (mean 2.49), irradiated by conventional visible light. No statistically significant differences were found for other comparisons.

## Discussion

### Bond failure rate

Previously only *in vitro* investigations have compared argon laser and conventional light-curing of orthodontic adhesives for bracket bonding. An *in vitro* tensile bond strength study by Kurchak *et al.* (1997) on Transbond XT pre-coated Victory series metal brackets demonstrated that 10 second curing with an argon laser at 250 mW

produced bond strengths comparable with those achieved with 20–40 second curing with a conventional curing light. Huck *et al.* (2000) found that argon laser curing of Transbond XT resin composite adhesive at 250 mW for 10 seconds provided shear bond strengths comparable with those after 20 seconds of curing with a regular light unit. Bond strengths after argon laser curing at three different energy levels (200, 230, and 300 mW) and conventional visible light curing of Transbond XT adhesive were compared by Talbot *et al.* (2000). Similar shear bond strengths were found for 10 seconds of argon laser-curing and 40 seconds of conventional visible light-curing, without any effect of the energy level used. James *et al.* (2003) evaluated the shear-peel bond strengths of plasma arc, argon laser, and conventional halogen light-cured Transbond XT and APC (Adhesive Precoated, 3M Unitek) adhesives and found a lower shear bond strength for the 10 second argon laser-cured APC when compared with the 20 second conventional halogen light-cured APC. However, shear bond strength was similar for the argon laser and halogen light when Transbond XT was used.

Although the manufacturer recommends 20 seconds of light curing, Oesterle *et al.* (1995) and Wang and Meng (1992) found that brackets bonded with Transbond XT and cured for 40 seconds had a stronger

**Table 3** Comparison of mean plaque scores for contralateral teeth.

	Sample size		Mean plaque score				<i>P</i> value
	Argon laser	Conventional light	Argon laser		Conventional light		
			Mean	SD	Mean	SD	
Canines	28	28	2.61	0.74	2.57	0.74	0.782
Lateral incisors	35	35	2.63	0.77	2.49	0.82	0.251
Central incisors	37	37	2.00	0.78	2.05	0.91	0.617

SD, standard deviation.

**Table 4** Comparison of mean plaque scores for adjacent teeth.

	Sample size		Mean plaque score				<i>P</i> value
	Argon laser	Conventional light	Argon laser		Conventional light		
			Mean	SD	Mean	SD	
Right canine/lateral	28	28	2.61	0.74	2.64	0.83	0.705
Right central/lateral	37	37	2.65	0.75	2.05	0.91	0.000
Left lateral/central	35	35	2.00	0.80	2.49	0.82	0.002
Left lateral/canine	28	28	2.57	0.74	2.39	0.83	0.225

SD, standard deviation.



bond than those cured for only 20 seconds. In the present study, a curing time of 40 seconds was used, allowing a direct comparison with most *in vitro* studies evaluating argon laser and conventional light-curing. Based on the results of the *in vitro* studies, the *in vivo* bond failure rate for argon laser-curing in the present investigation was expected to be similar to that of conventional light-curing. However, the overall bond failure rate for the argon laser (2.4 per cent) was found to be lower than for a conventional light-curing unit (5.7 per cent). A possible explanation might be the fact that the argon laser tip (0.5 mm in diameter) is very easy to manipulate and provides easy clinical access to posterior teeth, as opposed to the 7 mm diameter light guide of the conventional light-curing unit, thereby influencing the degree of polymerization *in vivo* (Figure 2).

#### *Incidence of decalcification and plaque accumulation*

Although a statistical difference in the incidence of decalcification was detected comparing the left lateral incisor (64.9 per cent), bonded using conventional light-curing, with the left central incisor (40.5 per cent), bonded using the argon laser, all other differences were not statistically significant. This suggests that argon laser-curing had no significant effect on the incidence of decalcification. A possible explanation for the one difference is the fact that the plaque scores, assessed after 12 months of treatment, and analysed in the same way, were also statistically different (left lateral incisor: 2.49; left central incisor: 2.00;  $P < 0.005$ ). Plaque is considered to be the main aetiological factor in caries development (Loesche, 1979). Also, a statistically significant difference between the incidence of decalcification was found between the maxillary central and lateral incisors, regardless of the curing method used (central incisors: 50.0 per cent; lateral incisors: 66.2 per

cent,  $P < 0.05$ ). This may have influenced the comparison of curing methods between adjacent teeth.

No clinical studies have previously examined the effect of argon laser-curing of orthodontic adhesives on the incidence of decalcification during treatment with fixed appliances. James *et al.* (2003) performed an *in vitro* investigation comparing microleakage of Transbond XT and APC used for bracket bonding, when cured by plasma arc, laser or conventional halogen light. No significant difference in microleakage was found between the argon laser and halogen light with either adhesive. Several *in vitro* investigations, examining the caries-preventive effect of argon laser irradiation on enamel, have reported a reduction in demineralization depth by 11.7–50 per cent after exposure to an acidic gel or solution (Yu *et al.*, 1993; Powell *et al.*, 1993; Hicks *et al.*, 1995; Flaitz *et al.*, 1995; Schouten *et al.*, 2000). However, no bonding procedure was involved. Hicks *et al.* (1993) compared the effects of argon laser (250 mW, 10 seconds, 12.5 J/cm<sup>2</sup>) and visible light polymerization of a pit and fissure sealant material on *in vitro* caries-like lesion initiation and progression using an acidified gel. Following the lesion initiation period (6 weeks), the primary surface lesion depth was significantly less ( $P < 0.05$ ) for the argon laser-cured group (97 µm) when compared with that for the visible light-cured group (151 µm). After an additional 4 week exposure, the primary surface lesion depth was still significantly less ( $P < 0.05$ ) for the argon laser-cured group (129 µm) when compared with that for the visible light-cured group (232 µm). Wall lesion occurrence was 5 per cent for both groups following the initiation period, and after the lesion progression period it was 5 and 15 per cent for the visible light-cured and argon laser-cured groups, respectively. Although this study involved an etching and bonding procedure, lesions were still created artificially in the absence of brackets, saliva, and other clinical factors.

Blankenau *et al.* (1999) performed a 5 week clinical pilot study on four volunteers, using modified orthodontic bands for plaque accumulation (Øgaard and Rolla, 1992), on premolars scheduled for extraction prior to orthodontic treatment. Polarized light microscopy revealed a 29.1 per cent reduction in lesion depth for teeth irradiated by argon laser (250 mW, 10 seconds, 12 J/cm<sup>2</sup>) when compared with control teeth (modified band, no laser-curing). Anderson *et al.* (2002) used the same procedure on nine volunteers to investigate the effectiveness of argon laser irradiation (325 mW, 60 seconds, 100 J/cm<sup>2</sup>) on caries prevention *in vivo* and found a 91.4 per cent reduction in average lesion depth, and a 94.6 per cent reduction in average lesion area compared with the control group. They also investigated the influence of pumicing and etching prior to argon laser irradiation and found a reduction in average lesion depth of 89.1 per cent and a reduction in average lesion



**Figure 2** Conventional light tip versus argon laser tip.

area of 92.2 per cent when compared with the control group. In the present study, no statistical difference was found between argon laser and conventional light-curing. However, this investigation was conducted under (nearly) normal clinical conditions including bracket bonding and unforced plaque accumulation. Treatment time was also significantly longer, and enamel surfaces were subjected to salivary flow and oral hygiene procedures. These factors may have influenced the demineralization/remineralization process. Because a microscopic evaluation of lesion depth and/or area was not possible under clinical circumstances, a different methodology was also used to evaluate the preventive effect of argon laser curing. The methodology was based on the hypothesis that if argon laser has a preventive effect on enamel, this would be reflected in a lower decalcification incidence. Although there was no difference in the incidence of decalcification found in the present study, a difference in surface area or depth of lesions between adhesive curing methods may have been present. Future clinical research should therefore focus on the development of a precise method of *in vivo* lesion surface area measurement for the evaluation of the caries-preventive effect of argon laser-curing.

### Conclusions

A statistically lower overall bond failure rate (2.4 per cent) was found for argon laser curing, when compared with conventional light-curing (5.7 per cent) ( $P < 0.05$ ). The reduced time used for argon laser-curing (10 seconds) did not result in a lower clinical bond strength when compared with the bond strength obtained with 40 seconds of conventional light-curing. Bond strength may be even higher. When bonding fixed appliances in the upper and lower arch, a reduction in the total curing time by approximately 10 minutes can be estimated. Therefore, the use of argon laser-curing seems to be superior to conventional light-curing with respect to clinical bond strength and chairside time. The incidence of decalcification was found to be similar for both curing methods.

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