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ORIGINAL

A STUDY ON THE BONDING EFFECT OF INVISIBLE APPLIANCE ATTACHMENT BY USING A MODIFIED RESIN-FILLED MIXING KNIFE FOR IMPROVED ORTHODONTIC TREATMENT IN ATHLETE PLAYERS

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ABSTRACT

Objective To evaluate the clinical effectiveness of modified resin-filled mixing knife on the attachment bonding of invisible appliance, so as to improve the efficiency and success rate of the attachment bonding. **Methods** Patients who were treated with invisible aligner in the Orthodontic Department were selected as the subjects and divided into two groups randomly with 800 attachments in each group. The experimental group used modified resin-filled mixing knife for attachment bonding, while the control group used traditional resin-filled mixing knife. The operation time and immediate success rate of all attachments were recorded. **Results** In the experimental group, the filling time of each attachment was (8.81±2.45) seconds, and the success rate of immediate bonding was 87.75%. In the control group, the filling time of each attachment was (12.22±3.70) seconds, and the success rate of instant bonding was 69.25%. There were statistically significant differences in the filling time and immediate success rate of each accessory between the two groups (P<0.05). **Conclusion** The use of modified resin-filled mixing knife can effectively shorten the filling time and improve the immediate bonding success rate of the attachment.

KEY WORDS: Invisible aligner; Attachment bonding; Modified resin-filled mixing knife；Traditional resin-filled mixing knife

In recent years, with the development of society, people have increasingly high requirements for aesthetics (Hannequin, Ouadi, Racy, & Moreau, 2020), while with the development of orthodontic materials and advances in medical technology, bracketless invisible aligners have been rapidly developed and widely used (Shen & Yu, 2021).Invisible bracketless orthodontics involves the use of a digital model of the jaw for 3D imaging using a computer and the corresponding software for orthodontic design. Invisible bracketless orthodontics allows for fine adjustment of both the way and process of tooth movement, resulting in a series of clear aligners that are worn and replaced by the patient on a step-by-step basis to achieve orthodontic results (Cohen, 2017). Attachments are an essential part of the invisible bracketless orthodontic procedure as a conventional auxiliary retention and tooth mobility device (Wang, 2021).Therefore, attachment bonding plays an important role in the treatment outcome of bracketless invisible orthodontics (Perkins et al., 2020). Clinically, attachments need to be formed by indirect light curing form after filling the resin into the aligner vacuole by four-handed operation of nurses. The indirect bonding of attachments often results in clinical operation with too much or too little attachment filling or dislodging of attachments, which seriously affects the course and outcome of treatment. Although the use of four-handed nursing operation in attachment bonding by nursing staff can reduce the operation time of attachment bonding and improve the success rate of attachment bonding to some extent (Büsching, Zhang, Schmid, Sigrist, & Khatami, 2021), the efficiency and success rate of attachment bonding in the case of four-handed operation are still not as expected due to the lack of attachment-specific fillers. This study attempts to use a modified mixer knife for attachment filling and compares it with the traditional type of mixer filling in order to provide a more efficient attachment bonding for clinical purposes (Almeida et al., 2019).

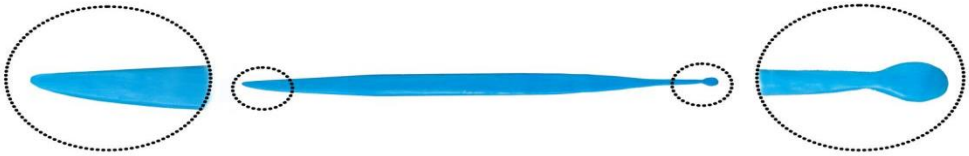
1. OBJECTIVES AND METHODS OF THE STUDY

1.1 Object of the study

INCLUSION CRITERIA: Patients between the ages of 18-35 years old, free of systemic and systemic diseases and dental dysplasia, with no bad habits, good communication, good attachment bonding cooperation, and requiring attachment bonding, who were seen in our orthodontic department between August and December 2019, were selected and randomly divided into control and experimental groups using the random grouping method. Both groups were operated by nurses with four hands, and the control group was filled with traditional plastic mixing knife for attachment filling (see Figure 1A), with a total of 800 attachments; the experimental group was filled with a modified

resin-filled mixing knife (see Figure 1B), with a total of 800 attachments. The accessory bonding operations were performed by two senior attending physicians and two supervising nurse practitioners with uniform training in both groups.

A Traditional type



B Modified type

Figure 1. Different types of resin-filled mixing knives

1.2 Research Methodology

1.2.1 Research materials

Both groups of attachment bonding materials were filled with Karisma light-curing resin produced by Heraeus, Germany, and cured by LED light-curing lamp of Hao Teeth valo, U.S.A. The control group used the traditional plastic mixing knife produced by GC, Japan, to fill the attachment, and the experimental group used an improved resin-filled mixing knife (Patent No. ZL201821550872.5) to fill the attachment (Jia et al., 2023; Kumar, Meena, Ranjan, & Kumar, 2023).

1.2.3 Attachment bonding method

The nurse uses a four-handed method to fill the resin filling material with different types of mixing knives into the non-bracketed invisible aligner attachment bonding stencil, which is worn into the arch in the form of an arch stencil for indirect light-curing bonding.

1.2.4 Research Methodology

According to the relevant literature, guidelines, and clinical expert consensus (Eliades, Papageorgiou, & Ireland, 2020; Ravera et al., 2016; Weckmann et al., 2020), the criteria for successful attachment bonding were developed (see Table 1), including four dimensions: detachment, shape, material, and position, and achievement of all four dimensions simultaneously represents

successful bracketless invisible orthodontic attachment bonding, and failure of any one of these dimensions is considered as attachment bonding failure.

Table 1. Indicators for measuring the success of bonding invisible bracketless orthodontic attachments

Dimensional Criteria	Measurement standard indicators	Content of the measurement criteria
Shedding	No detachment of attachments	Attachment not detached following the invisible aligner
Shape	No defective attachment integrity	The attachment is completely bonded to the tooth surface, the attachment is intact without bubbles and other kind of defects
Filling volume	No more material around the attachment	The material is properly filled and no excessive material spillage after curing
Other	Attachment bonding position is correct	The attachment is bonded in a position that allows the invisible aligner to achieve the desired effect

1.2.4 Statistical methods

SPSS 22.0 statistical software was used for statistical analysis of the data. The measurement data were described by the mean ± standard deviation ($\bar{x}\pm s$), and the count data were described by the number of cases and percentages. x^2 test and t-test were used to compare the two groups before and after the intervention, and the difference was considered statistically significant at $P < 0.05$.

2. RESULTS

2.1 The filling time of the attachment in the experimental group was significantly less than that in the control group

The filling time of the attachment was (8.81±2.45s) in the experimental group and (12.22±3.70s) in the control group, and the difference was statistically significant (P<0.00) when comparing the filling time of the two groups, as shown in Table 2.

Table 2. Table comparing the length of filling per attachment before and after intervention in both groupsd

N=800

Group	Average time (sec)	T	P
Experimental group	8.81±2.45	5.436	0.000
Control group	12.22±3.70		

2.2 The success rate of attachment bonding was significantly higher in

the experimental group than in the control group.

The number of successful cases of attachment bonding in the experimental group was 722, with a success rate of 90.25%, and the number of successful cases of attachment bonding in the control group was 554, with a success rate of 69.25%, with statistically significant differences in the results (P < 0.00), as shown in Table 3.

Table 3. Comparison of the success rate of accessory bonding before and after the intervention in the two groups

N=800

Group	Bonding results (number of pellets/percentage)		X^2	P
	Success	Failure		
Experimental group	722/90.25	78/9.75	109.230	0.000
Control group	554/69.25	246/30.75		

2.3 The number of failed attachment bonding in each dimension was lower in the experimental group than in the control group.

There were 18 detached attachments in the experimental group and 66 in the control group; 16 attachments with defective shape in the experimental group and 38 in the control group; 32 attachments with unreasonable taking (too much or too little) in the experimental group and 100 in the control group; 8 attachments with wrong position in the experimental group and 30 in the control group; 4 attachments with other reasons in the experimental group and 12 in the control group. See Figure 2.

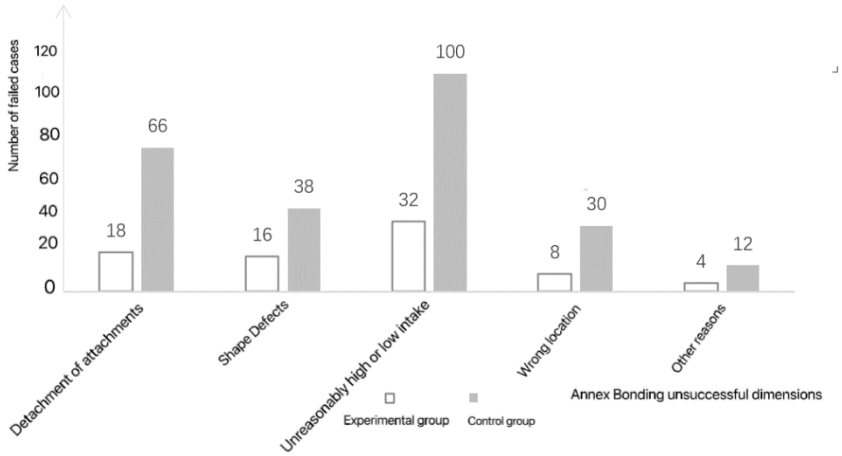


Figure 2. Failure of each dimension of attachment bonding before and after intervention in both groups

3. DISCUSSION

3.1 Clinical usefulness of the modified resin-filled mixing knife

The modified resin-filled mixing knife improves the success rate of attachment bonding and reduces the operation time (Abbas, Sayed, Samir, & Abeed, 2021; Dickerson et al., 2012). In bracketless invisible orthodontics, attachments are an important adjunct to invisible orthodontics, allowing the aligners to fit snugly on the tooth surface, enhancing retention and assisting tooth movement to maximize the treatment effect (Appleby et al., 2019; Jiang et al., 2020). The results of this paper show that the use of a modified resin-filled mixing knife increases the success rate of attachment bonding and reduces the operation time. On the one hand, this may be related to the use of a resin-filled blender (Larsson, Virtamo, & Wolk, 2012; Maida, Norrito, Daidone, Tuttolomondo, & Pinto, 2020). Too much or too little resin filling can reduce the effectiveness of invisible orthodontic treatment (Jia et al., 2023).The operation end of the traditional plastic mixing knife is semi-circular and large in diameter, so it is not easy to complete the fine operation of resin material filling and trimming during attachment bonding, and the operation time is long, the utility model patent - special resin filling and mixing knife, with a small round end and a pointed end, the small round end is conducive to the taking and filling of composite resin materials, and when the resin is lightly pressed, it can be filled into the attachment template smoothly, and the pointed end is easy to scrape off and trim the excess resin, which improves the success rate of attachment bonding and the efficiency of medical care cooperation (Sims & Yew, 2017). On the other hand, it may be because of four-handed operation, a study showed (Mariniello) that four-handed operation can improve the quality and time of operation, and four-handed operation can bring into play the subjective initiative of nurses, who are familiar with the treatment process before treatment, timely transfer of instruments and materials during treatment, active cooperation and effective, timely saliva absorption and effective light curing, so that the doctor's operation time can be reduced and secondary contamination of the dental surface after acid etching can be effectively prevented (Zhu et al., 2021).

The orthodontic process of attachment bonding affects the orthodontic orthodontic effect, the researcher before the intervention study according to the literature reviewed the indicators of the measure of success of attachment bonding into four dimensions of detachment, shape, material, position, and after the experiment found that there is a category of patients with attachment bonding failure reasons are not in the measure, and the specific reasons are not clear, which need to be continued to explore and analyze in the follow-up care with quality study.

3.2 Modified resin-filled mixing knife is less expensive to produce and easy to prevent cross-contamination

The resin filler is made of high temperature and high pressure resistant plastic, easy to clean, autoclave sterilization and preservation; with a two-

head design, one end of the material to take, one end of the material correction, one person and one use, effectively prevent cross infection.

3.3 Deficiency improvement

The application of resin fillers has facilitated the bonding of bracketless invisible orthodontic attachments (Tamer, Öztaş, & Marşan, 2019), but the lack of width of the rounded end of the resin filler at the link with the shank makes it easy to break during use, so efforts should be made to find more suitable materials to improve its service life in the future.

4. CONCLUSION

Invisible bracketless aligners have become a common orthodontic method in clinical practice. As the proportion of invisible bracketless aligners in clinical use increases, how to fill attachments quickly and accurately and with a high success rate of adhesive bonding at one time has become an urgent problem for clinical orthodontic caregivers. The modified resin-filled mixing knife shortens the attachment filling time to a certain extent, improves the success rate of attachment bonding, and thus improves the efficiency of medical personnel, which has certain clinical practical significance.

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