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THE EFFECT OF FLUORIDE RELEASING BONDING AGENT ON MECHANICAL PROPERTIES OF ENAMEL- AN IN VITRO STUDY

Orthodontics

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ABSTRACT

Aim- To evaluate the effect of fluoride releasing bonding agent on mechanical properties of enamel. **Material And Method-** 44 extracted premolar teeth free of any caries or pathology were taken and sliced in their long axis. The samples were equally divided into 4 groups- group 1: control group, group 2: Transbond XT, group 3 : Orthosolo, group 4: Rely A Bond. After keeping the samples in remineralising solution for 40 hours the hardness and roughness of the samples were tested by Vickers hardness testing machine and TIME 3200 roughness tester. Following this the samples were treated with their respective group's bonding agent and kept in demineralizing solution for 96 hours. The hardness and roughness were again measured and the results were statistically analysed. **Result-** The study revealed a significant decrease in hardness and increase in surface roughness across all groups after exposure to a demineralizing solution. The Control Group showed the greatest decrease in hardness, while the Orthosolo Group displayed the least, indicating its resistance. Ortho Solo also exhibited the least increase in surface roughness. Transbond XT and Rely A bond groups differed significantly from the Control Group, suggesting their effectiveness in maintaining enamel properties. No significant difference was found between the Control Group and Transbond XT in hardness after exposure. Orthosolo and Rely A bond groups showed superiority in preserving enamel hardness. **Conclusion:** Orthosolo, outperformed others in maintaining enamel hardness and surface roughness. Transbond XT and Rely A bond also showed promise in preserving enamel mechanical properties.

KEYWORDS

INTRODUCTION

Fluoride, a naturally occurring element found in minerals and water, plays a vital role in oral health by strengthening tooth enamel and protecting against decay. Its incorporation into dental care routines enhances enamel resilience by promoting remineralization, thus preventing dental caries. Specifically, fluoride interacts with dental tissues to create fluorapatite, a mineral more resistant to acid dissolution, effectively safeguarding enamel integrity.

In orthodontic treatment, fluoride-releasing bonding agents have emerged as a significant advancement. These agents not only facilitate tooth movement but also bolster enamel strength and reduce demineralization risk. By forming a protective barrier around brackets, they gradually release fluoride ions, promoting enamel remineralization and counteracting acid-producing bacteria's harmful effects.

Fluoride-releasing bonding agents contribute to enamel hardness and surface smoothness, crucial factors in dental health. The presence of fluoride ions enhances enamel hardness, making it more resilient to acid attacks during orthodontic treatment. Moreover, these agents help maintain a smoother enamel surface compared to traditional bonding agents, reducing plaque accumulation and enhancing oral hygiene.

The benefits of fluoride-releasing bonding agents extend beyond orthodontic treatment, impacting overall oral health and esthetic outcomes. By evaluating their effects on enamel hardness and surface roughness, this study aims to provide valuable insights into their role in enhancing dental health and optimizing orthodontic treatment outcomes.

MATERIALS AND METHODS

Source Of Data

The present study was carried in Department of Orthodontics and Dentofacial Orthopaedics in collaboration with Research Lab facility at ITS Dental college, Hospital and Research Center, Greater Noida, Uttar Pradesh (India) .

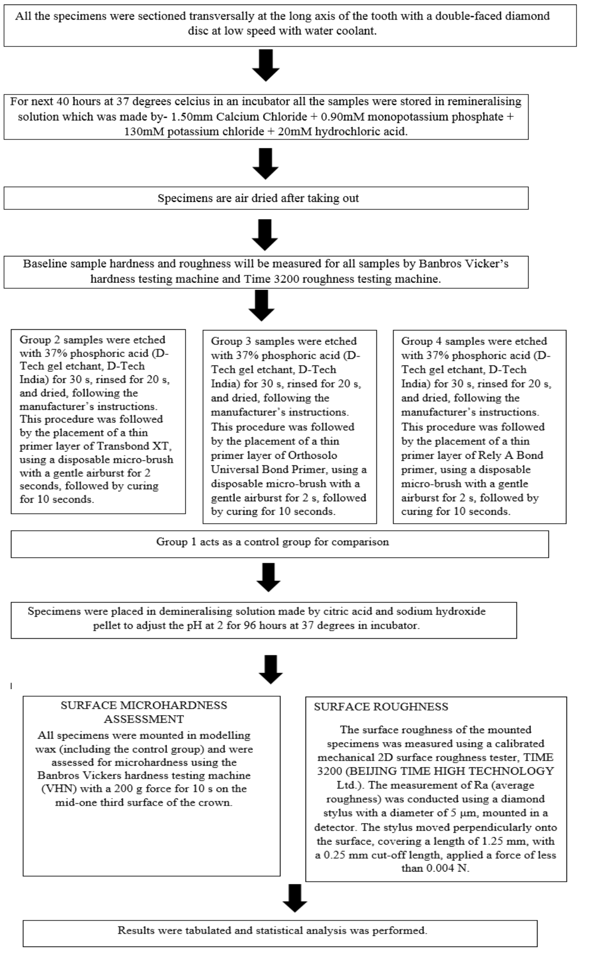
Inclusion Criteria:

- Sound extracted premolar teeth

Exclusion Criteria:

- Teeth with pre existing caries
- Teeth with white spot lesions
- Teeth with pre existing restoration
- Teeth with developmental pathology

Sample Preparation:



Statistical analysis:
The collected data was analysed statistically by:
Independent sample t test was used for intergroup comparison and paired t test was used for intragroup comparison for hardness and roughness measurements before and after exposure to demineralizing solution.

Based on the statistical analysis, the following results were obtained,

RESULTS

The present study was conducted at ITS Dental College, Hospital and Research Centre, Greater Noida, in order to evaluate the effect of fluoride releasing bonding agent on mechanical properties particularly hardness and surface roughness of enamel. Ours is an in vitro study performed on 44 extracted teeth divided into 4 groups
The 4 groups consisting of 11 teeth each:-
Group I – Control group
Group 2 – Tranbond XT group
Group 3 – Orthosolo group
Group 4 – Rely A bond group

Table 1- Comparison of mean hardness values before and after exposure to demineralising solution for Control Group

Group	Sample size	Mean	Standard Deviation	P-Value
Before	11	278.055	14.988	0, S
After	11	104.213	5.020	

Table 1 shows that on comparing, the values for hardness before and after exposure to demineralising solution, it can be noted that there was a statistically significant decrease for the same. The mean value of hardness for control group before exposure to demineralising solution lies at 278.055± 14.988 whereas the after value has decreased to 104.213±5.020.

Table 2- Comparison of mean hardness values before and after exposure to demineralising solution for Transbond XT Group

Group	Sample size	Mean	Standard Deviation	P-Value
Before	11	276.276	16.574	0, S
After	11	106.429	6.544	

From table 2 it can be noted that on comparing, the values for hardness before and after exposure to demineralising solution, it can be noted that there was a statistically significant decrease for the same. The mean value of hardness for the Transbond XT group before exposure to demineralising solution lies at 276.276±16.574 whereas the after value has decreased to 106.429±6.544.

Table 3- Comparison of mean hardness values before and after exposure to demineralising solution for Orthosolo Group

Group	Sample size	Mean	Standard Deviation	P-Value
Before	11	275.884	19.272	0, S
After	11	162.438	9.062	

Table 3 depicts that on comparing, the values for hardness before and after exposure to demineralising solution, it can be noted that there was a statistically significant decrease for the same. The mean value of hardness for the Orthosolo group before exposure to demineralising solution lies at 275.884±19.272 whereas the after value has decreased to 162.438±9.062.

Table 4- Comparison of mean hardness values before and after exposure to demineralising solution for Rely A bond Group

Group	Sample size	Mean	Standard Deviation	P-Value
Before	11	273.921	9.983	0, S
After	11	119.195	5.263	

As can be seen in table 4 on comparing, the values for hardness before and after exposure to demineralising solution, it can be noted that there was a statistically significant decrease for the same. The mean value of hardness for the Rely A bond group before exposure to demineralising solution lies at 273.921±9.983 whereas the after value has decreased to 119.195±5.263.

Table 5- Intergroup comparison of Hardness Before And After Exposure To Demineralising Solution

Hardness	Before treatment	After Treatment
Control Group	278.055	104.212
Transbond XT Group	276.276	106.429
Ortho solo group	275.883	162.438
Rely A bond group	273.920	119.194

Among the groups, the Orthosolo Group experienced the least decrease in mean hardness values after exposure to the demineralizing solution, dropping from 275.883 to 162.438. On the other hand, the control group had the most substantial decrease, with mean hardness values decreasing from 278.055 to 104.212. This suggests that the application of Orthosolo on sample's hardness was relatively more resistant to the effects of the demineralizing solution compared to the other groups.

Table 6- Intergroup comparison of significance of mean hardness values after exposure to demineralizing solution

S. No	Groups	P value	Significance
1	Control	0.383	Non Significant
	Transbond XT		
2	Control	0	Significant
	Orthosolo		
3	Control	0	Significant
	Rely A bond		
4	Transbond XT	0	Significant
	Orthosolo		
5	Transbond XT	0	Significant
	Rely A bond		
6	Orthosolo	0	Significant
	Rely A bond		

Table 6 depicts that, there is no statistically significant difference in hardness values between the control group and the Transbond XT group after exposure to the demineralizing solution.

On comparing, the orthosolo group and control group, it is noted that there is a statistically significant difference between the two, suggesting Orthosolo is better at preserving the surface hardness than the control group.

Among Rely A bond and control group a statistically significant difference is noted between the two, suggesting Rely A bond is better at preserving the surface hardness than the control group.

On comparing, Transbond XT group with the Orthosolo group, it is noted that there is a statistically significant difference between the two, suggesting Orthosolo is better at preserving the surface hardness than the Transbond XT group.

Between Transbond XT group and Rely A bond group, there is a statistically significant difference between the two, suggesting Rely A bond is better at preserving the surface hardness than the Transbond XT group.

On comparing, Orthosolo group with the Rely A bond group, there is a statistically significant difference between the two, suggesting Ortho solo is better at preserving the surface hardness than the Rely A bond group.

Table 7- Comparison of mean roughness values before and after exposure to demineralising solution for Control Group

Group	Sample size	Mean	Standard Deviation	P-Value
Before	11	0.78345	0.032	0, S
After	11	1.67473	0.177	

Table 7 shows that on comparing, the values for roughness before and after exposure to demineralising solution, it can be noted that there was a statistically significant decrease for the same. The mean value of roughness for control group before exposure to demineralising solution lies at 0.78345± 0.032 whereas the after value has decreased to 1.67473±0.177.

Table 8- Comparison of mean roughness values before and after exposure to demineralising solution for Transbond XT Group

Group	Sample size	Mean	Standard Deviation	P-Value
Before	11	0.78391	0.028	0, S
After	11	1.26045	0.096	

From table 8 it can be noted that on comparing, the values for roughness before and after exposure to demineralising solution, it can be noted that there was a statistically significant decrease for the same. The mean value of roughness for Transbond XT group before exposure to demineralising solution lies at 0.78391± 0.028 whereas the after value has decreased to 1.26045±0.096.

Table 9- Comparison of mean roughness values before and after exposure to demineralising solution for Orthosolo Group

Group	Sample size	Mean	Standard Deviation	P-Value
Before	11	0.78082	0.025	0, S

After	11	1.02118	0.065	

As can be seen from table 9 on comparing, the values for roughness before and after exposure to demineralising solution, it can be noted that there was a statistically significant decrease for the same. The mean value of roughness for Orthosolo group before exposure to demineralising solution lies at 0.78082± 0.025 whereas the after value has decreased to 1.02118±0.065.

Table 10- Comparison of mean roughness values before and after exposure to demineralising solution for Rely A bond Group

Group	Sample size	Mean	Standard Deviation	P-Value
Before	11	0.766010	0.0340	0, S
After	11	1.25573	0.066	

On comparing, the values for roughness before and after exposure to demineralising solution, it can be noted that there was a statistically significant decrease for the same. The mean value of roughness for Orthosolo group before exposure to demineralising solution lies at 0.78082± 0.025 whereas the after value has decreased to 1.02118±0.065.

Table 11- Intergroup Comparison of Mean Roughness Values Before And After Exposure To Demineralising Solution

Roughness	Before treatment	After treatment
Control Group	0.7834	1.6747
Transbond Group	0.7839	1.2604
Ortho solo group	0.7808	1.0211
Rely a bond group	0.7660	1.2557

Among the groups, the Ortho Solo group had the least increase in mean roughness values after exposure to the demineralizing solution, going from 0.7808 before to 1.0211 after treatment. On the other hand, the Control Group experienced the most substantial increase, with mean roughness value rising from 0.7834 before to 1.6747 after treatment. This suggests that the Ortho Solo group's surface was relatively more resistant to the effects of the demineralizing solution compared to the other groups.

Table 12- Intergroup Comparison of significance of mean hardness values after exposure to demineralizing solution

S. No	Groups	P value	Significance
1	Control	0	Significant
	Transbond XT		
2	Control	0	Significant
	Orthosolo		
3	Control	0	Significant
	Rely a bond		
4	Transbond XT	0	Significant
	Orthosolo		
5	Transbond XT	0.894	Significant
	Rely A bond		
6	Orthosolo	0	Significant

As can be observed from table 12, there is statistically significant difference in roughness values between all the groups after exposure to the demineralizing solution.

DISCUSSION

The study aimed to investigate the effects of a fluoride-releasing orthodontic bonding agent on enamel mechanical properties, particularly hardness and surface roughness. Comparisons were made among three bonding agents and a control group using 44 premolar teeth extracted for orthodontic purposes. Microhardness analysis, employing the Vickers Hardness Measuring method, provided precise and quantitative assessments of enamel integrity. Despite slight variations in evaluation locations, the consistency of microhardness across points underscores its suitability as a representative measure of enamel surface hardness.

Lehman et al. (1981) reported a decrease in microhardness values following enamel etching, with subsequent recovery noted in the presence of fluoride. In contrast, **Collys** et al. (1993) observed microhardness recovery when etched enamel was subjected to the oral environment alongside fluoride exposure.

In their study, **Hu and Featherstone** (2005) observed a notable finding that teeth treated with fluoride varnish exhibited a 30% decrease in demineralization compared to control teeth, enamel-etched teeth, and those treated with a light-cured unfilled sealant.

In our study, all groups, including the Control, Transbond XT, Ortho Solo GP, and Rely A Bond GP, exhibited a significant decrease in hardness after exposure to the demineralizing solution, indicating its efficacy in altering the orthodontic agents' material properties. While comparisons between the Control Group and Transbond XT Group yielded non-significant differences in mean hardness, significant disparities were observed when comparing the Control Group with Ortho Solo GP and Rely A Bond GP. The Ortho Solo GP group displayed less reduction in hardness compared to both the Transbond XT and Rely A Bond GP groups, highlighting potential resistance to demineralization. Conversely, the Control Group experienced the most substantial decrease in hardness, underscoring its heightened susceptibility to demineralizing effects.

In **Fatemeh Molaasadolah's** study (2017), the surface microhardness values were consistently within the range of 227.2 kg/mm² before fluoride application. The research aimed to assess the impacts of two fluoride varnishes (Duraflor varnish and Ariadent Iranian varnish). The findings indicated a significant increase in enamel microhardness in both varnish groups, whereas no such increase was observed in the control group.

Although both Orthosolo and rely a bond are fluoride releasing bonding agents still it was found that Orthosolo maintained a more modest hardness post exposure to demineralising solution when compared to Rely A bond group.

A possible explanation for the observed phenomenon could be attributed to the lower fluoride release from the Rely A bond agent. In **Ashish Kumar Barik's** study (2020), conducted to compare fluoride release from RelyA bond, it was found that the maximum fluoride concentration released was 0.14067 ppm on day 1. However, there was a significant decrease in fluoride release from day 1 to day 2. This decrease might be due to the initial release of surface-locked fluoride into the sample solution on day 1. Additionally, the amount of fluoride released from beneath the brackets was minimal, as only the edges of a thin film of adhesive were exposed to the medium. Furthermore, it was observed that the fluoride release from RelyA bond was lower compared to the fluoride release from the light-cure bonding agent (Light Bond) at every measurement time point.

Surface roughness measurements were conducted using a Time3200 roughness testing machine, which utilizes a stylus to make physical contact with the surface being examined. As the stylus traverses the surface, its vertical movements generate an electrical signal that is converted into digital data, allowing for the calculation of essential parameters such as Ra and Rz. Results obtained before and after treatment with a demineralizing solution were compared across different orthodontic groups.

The Control Group exhibited a significant increase in mean roughness after treatment, indicating a substantial change in surface texture. Conversely, the Ortho Solo Group consistently showed less pronounced increases in roughness, suggesting a relative resistance to the effects of the demineralizing solution. Demineralization compromises enamel integrity, leading to increased surface irregularities and porosity, which in turn promote plaque accumulation and bacterial adhesion. Regular oral hygiene practices, fluoride treatments, and remineralization therapies are essential for maintaining a smoother enamel surface and preserving overall dental health.

In his in vitro study, **E. K. Basdra** investigated the inhibition of enamel demineralization and observed alterations on the enamel surface after the use of fluorobond and Rely A bond. Scanning electron microscopy revealed microglobular particle depositions on the enamel surface following the application of these adhesives. These particles are likely deposits of calcium fluoride, a salt known for its cariostatic properties. The results of the study suggest that fluoride-releasing orthodontic bonding systems, such as those examined, may offer an added level of protection against caries susceptibility in patients with fixed appliances, albeit for a limited duration.

In contrast, a clinical trial performed in 1999 by **Christopher J. Wenderoth** to examine the barrier effect of dual-cured lightly filled BIS-GMA fluoride-releasing sealant on white spot formation, gingival irritation, and plaque accumulation during fixed orthodontic therapy, revealed that there was no significant difference (P > .05) observed in the decalcification rates between the treatment and control groups.

The investigation revealed that the Ortho Solo group displayed the least reduction in hardness post-demineralization, suggesting its potential as a more resilient bonding agent compared to Transbond XT and Rely A Bond. Additionally, fluoride incorporation, particularly in the Ortho Solo bonding agent, showed a protective effect on enamel hardness. Despite all groups experiencing increased roughness post-treatment, the Ortho Solo group consistently exhibited the smallest rise, indicating its potential superiority in maintaining a smoother enamel surface compared to other bonding agents.

CONCLUSION:

The fluoride-releasing bonding agent, Ortho Solo, demonstrated superior performance in preserving enamel hardness and surface roughness when exposed to a demineralizing solution. Transbond XT and Rely A bond groups also exhibited positive effects compared to the Control Group, suggesting their potential in maintaining enamel mechanical properties.

The study's in vitro nature provides valuable insights into the comparative effectiveness of bonding agents, paving the way for potential improvements in dental practices. The findings emphasize the importance of selecting bonding agents with fluoride-releasing properties to enhance the longevity and resilience of dental restorations.