Original Article

# Treatment of Class II Malocclussion: A Comparative Study of the Effects of Twin-block and Fatigue Resistant Device

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**Abstract**

**Aim:** This is a retrospective cephalometric study aimed to compare the treatment effects of Twin-Block (TB) appliance with The Forsus Fatigue Resistant Device (FRD) appliance in class II division I patients in a composite of peak and post peak growth of period time. **Materials and Methods:** The experimental sample consisted of the lateral cephalograms of 40 patients who were treated with either TB appliance ($n$ = 15), FRD ($n$ = 15) or the untreated control ones. In treatment groups lateral cephalograms taken before therapy as initial records (T1) and at the completion of functional therapy (T2) were used. The control group comprised 10 children with untreated skeletal Class II malocclusions. The normality of distribution of continuous variables was tested by Shaphiro wilk test. Oneway ANOVA and LSD test in parametric; Kruskall Wallis and all pairwise multible comparison tests in non-parametric samples were used for comparing differences among 3 groups. **Results:** Cephalometric analysis revealed that both TB and FRD appliances stimulated mandibular growth ($P < 0.05$) and no restriction was seen in maxilla in both groups ($P > 0.05$). The unwanted mandibular proclination was seen more in FRD group ($P \leq 0.001$). Soft tissue didn't imitate the hard tissue ($P > 0.05$). **Conclusion:** FRD group produced skeletal effects as much as TB group in peak and post peak period of growth with still more mandibular incisor proclination.

**Keywords:** *Cephalometrics, forsus fatigue resistant device, functional appliances, functional theraphy, twin block*

**Date of Acceptance:** 11-Sep-2018

## Introduction

The most common skeletal problem in orthodontics is the Class II malocclusion, which is usually characterized by mandibular retrognathia.[1] Several removable or fixed functional appliances are used for treatment of growing Class II division I malocclusions with mandibular retrognathia in order to stimulate mandibular growth by a forward positioning of the mandible. Along with some dentoalveolar effects, stimulation in the growth of condylar cartilage, displacement of the condyle in the glenoid fossa, and a lengthening of the mandible form the skeletal effects of functional treatment.

The twin-block (TB) was developed by Clark,[2] for use in the correction of Class II malocclusions. The appliance consists of maxillary and mandibular acrylic plates with bite blocks and anterior vestibular arches that posture the mandible forward on closure. TB belongs to the removable type of functional appliances and is designed for full-time wear to take advantage of all functional forces applied to the dentitions. In the literature, it was shown many times that the correction mechanism of TB is formed by both dental and skeletal changes[3-5] But, the percentage of the treatment contribution rate of dental or skeletal correction is conflicting. As there are studies claiming that skeletal changes were predominant over the dental changes,[6] also there are studies attributing the most of the overjet reduction to the dentoalveolar changes in TB treatment.[4,7]

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/njcp.njcp_110_18

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**How to cite this article:** Gulec A, Goymen M. Treatment of Class II malocclussion: A comparative study of the effects of twin-block and fatigue resistant device. Niger J Clin Pract 2018;21:1557-63.

The Forsus fatigue resistant device (FRD) (3M Unitek Corp, Monrovia, CA, USA) is an increasingly popular fixed functional appliance that was first described by Vogt[8] in 2006. FRD is an interarch push-spring composed of a spring module that attaches to the headgear tube and a push-rod that attaches to the lower arch-wire either mesial or distal to the first bicuspid.[8] The correction mechanism of FRD is typically due to distal and intrusive movement of maxillary molars, medial movement of mandibular molars, retrusion of maxillary incisors, and labial tipping of mandibular incisors. With these dental movements, varying amounts of skeletal effects of FRD have been reported in previous studies.[9,10]

In clinical practice, the functional treatment protocols used in Class II mandibular retrusion subjects vary especially according to the maturity of the patients; thus, the purpose of this study was to compare the dental, skeletal, and soft tissue effects of two preferred full-time wear functional appliances (TB and FRD) in relatively broad growth of period time (peak and post peak) together with a control of untreated Class II subjects.

## Materials and Methods

### Study samples

This retrospective study was approved by the Ethics Committee of Gaziantep University. Study samples were determined according to the following inclusion criteria:

Angle Class II Division 1 malocclusion with at least half cusp Class II molar relationship and a retrognathic mandible, treated with either TB or FRD appliance, postpeak growth period and being in permanent dentition for treatment groups and Angle Class II Division 1 malocclusion with at least half cusp Class II molar relationship and a retrognathic mandible, postpeak growth period and being in permanent dentition for control group.

In both treatment groups, the growth period of the patients was defined using the cervical vertebral maturation index (CVMI) and patients were selected within the CVMS III-V[11] in T1 records.

In FRD group, pretreatment cephalometric records (T1), which were taken just before the insertion of FRD, and the posttreatment cephelometric records (T2), which were taken just after the removal of FRD, were used. Treatment with the FRD lasted 0.5 years on average.

In TB group, records that were taken at the beginning of the treatment were used as pretreatment T1 records and the records that were taken just after the removal of TB were used as posttreatment T2 records. The treatment protocol used for TB patients was full-time wear of TB (with the exception of eating time). Treatment with the TB lasted 1.1 year on average.

In the control group, T1 records consisted of the films taken at the initial consultation and T2 records consisted of the radiographic records taken immediately before the start of orthodontic treatment (average 6-month patient follow-up period).

According to the power analysis, sample size determination revealed that for the analysis of variance (ANOVA) on three groups with an effect size of 0.66 for the ANB angle, an alpha level of 0.05, and a power of 0.9, a minimum of 12 subjects in each group was required. Thus, as a result of this scanning procedure, suitable 40 patients were grouped as like this: TB group consisted of 15 patients (8 females and 7 males; mean age: 12.18 ± 2.19) treated with TB. FRD group consisted of 15 patients (8 females and 7 males: mean age: 12.98 ± 219) treated with FRD, and control group consisted of 10 patients (7 females and 3 males; mean age: 12.77 ± 1.62). Although the number of subjects in control group are under the intended sample size, as the intragroup SD amount is very similar in this group, 10 patients were considered adequate.

### Cephalometric analysis

One of the investigators (MG) calibrated, digitally traced, and collected the skeletal, dental, and soft tissue measurements using Dolphin software version 11.7 (Dolphin Imaging Systems, Chatsworth, CA, USA). The measurements used in this study were as follows:

Sella–nasion–A point (SNA), sella–nasion–B point SNB, A point–nasion–B point (ANB), gonion gnathion–sella nasion (GOGN-SN), sella gonion–nasion menton (SGO-NME) angles and Wits, condilion–A point (Co-A), and condilion–gnathion (Co-Gn) distances as skeletal measurements; upper incisor–frankfurt horizontal (U1-FH), lower incisors–mandibular plane (IMPA) angles and overbite, and overjet distances as dental measurements; and upper lip to E line and lower lip to E line distances as soft tissue measurements.

To determine the method error, 15 lateral cephalometric radiographs were randomly selected and retraced at a 2-week interval by the same operator (MG). The intraexaminer reliability for the cephalometric variables was analyzed with the intraclass correlation coefficient.

The normality of distribution of continuous variables was tested by Shapiro–Wilk test. One-way ANOVA and LSD test were used the compare variables among three groups, when data were normally distributed and Kruskal-Wallis analysis and "all pairwise" multiple comparison test were used when data were not normally distributed. Paired samples *t*-test was used to compare treatment outcomes within groups. Data are expressed as mean ± standard deviation. Statistical analysis was performed by using SPSS version 24 for Windows and a $P$ value <0.05 was accepted as statistically significant.

## Results

The mean age at onset of treatment was 12.13 ± 0.58 in the TB group, 14.47 ± 0.62 in the FRD group, and 13.00 ± 0.58 in the control group.

**Table 1: Means, standard deviations and p values for the measurements among groups**

| | | Groups | | | *P* between groups | | | |
|---|---|---|---|---|---|---|---|---|
| | | TWB (*n*=15) Mean change±SD | FRD (*n*=15) mean change±SD | CONTROL (*n*=10) mean change±SD | All Groups | TB vs FRD | TB vs Control | FRD vs Control |
| Skeletal effects | | | | | | | | |
| SNA (°) | T1 | 81.04±1.00 | 83.37±1.21 | 82.36±0.73 | 0.276 | | | |
| | T2 | 79.06±1.16 | 82.35±0.91 | 82.33±1.15 | 0.051 | | | |
| | $P_{within\ groups}$ | 0.005§ | 0.087 | 0.963 | | | | |
| SNB (°) | T1 | 75.62±1.15 | 78.05±0.78 | 75.75±0.95 | 0.146 | | | |
| | T2 | 74.95±1.23 | 78.44±0.76 | 76.11±1.00 | 0.049* | 0.016** | | |
| | $P_{within\ groups}$ | 0.218 | 0.377 | 0.474 | | | | |
| ANB (°) | T1 | 5.4±0.67 | 5.34±0.75 | 6.46±0.71 | 0.533 | | | |
| | T2 | 4.11±0.51 | 3.91±0.49 | 6.53±0.62 | 0.004* | | 0.004 ** | 0.002 ** |
| | $P_{within\ groups}$ | 0.002§ | 0.005§ | 0.840 | | | | |
| GOGN-SN(°) | T1 | 30.92±6.15 | 29.89±6.79 | 34.69±5.81 | 0.177 | | | |
| | T2 | 32.13±6.20 | 29.40±5.63 | 33.57±5.77 | 0.205 | | | |
| | $P_{within\ groups}$ | 0.053 | 0.377 | 0.139 | | | | |
| SGO-NME% | T1 | 67.28±4.02 | 67.49±5.72 | 64.31±4.55 | 0.233 | | | |
| | T2 | 66.43±3.75 | 68.28±4.80 | 66.53±4.14 | 0.438 | | | |
| | $P_{within\ groups}$ | 0.166 | 0.309 | 0.005§ | | | | |
| Wits (°) | T1 | 5.37±0.86 | 3.07±0.91 | 6.15±1.21 | 0.081 | | | |
| | T2 | 2.79±0.77 | 0.47±0.89 | 5.87±1.36 | 0.003* | | 0.039 ** | 0.001** |
| | $P_{within\ groups}$ | 0.002§ | 0.009§ | 0.493 | | | | |
| Co-A (mm) | T1 | 81.65±11.21 | 83.31±6.08 | 80.39±2.75 | 0.198 | | | |
| | T2 | 81.83±7.67 | 83.91±6.26 | 77.93±4.22 | 0.084 | | | |
| | $P_{within\ groups}$ | 0.782 | 0.796 | 0.527 | | | | |
| Co-Gn (mm) (mm) | T1 | 105.79±14.56 | 111.6±10.31 | 105.44±5.05 | 0.74 | | | |
| | T2 | 109.95±13.59 | 115.05±10.21 | 101.80±4.34 | 0.016 * | | | 0.004 ** |
| | $P_{within\ groups}$ | 0.071 | 0.439 | 0.058 | | | | |
| Dental effects | | | | | | | | |
| U1-FH (°) | T1 | 116.13±10.99 | 111.99±11.38 | 110.99±14.05 | 0.505 | | | |
| | T2 | 111.43±9.44 | 111.61±7.50 | 112.70±14.29 | 0.951 | | | |
| | $P_{within\ groups}$ | 0.031§ | 0.894 | 0.245 | | | | |
| IMPA (°) | T1 | 96.08±5.39 | 94.39±6.79 | 92.35±5.99 | 0.288 | | | |
| | T2 | 99.39±6.47 | 101.71±8.43 | 93.78±6.22 | 0.035 * | | | 0.011** |
| | $P_{within\ groups}$ | 0.197 | 0.001§ | 0.206 | | | | |
| Overbite (mm) | T1 | 2.79±2.46 | 2.42±1.73 | 3.22±2.05 | 0.651 | | | |
| | T2 | 2.86±2.35 | 0.63±1.39 | 2.79±1.86 | 0.005 * | 0.003□ | | 0.009** |
| | $P_{within\ groups}$ | 0.891 | 0.000§ | 0.286 | | | | |
| Overjet (mm) | T1 | 6.91±3.83 | 5.52±3.60 | 7.12±2.80 | 0.443 | | | |
| | T2 | 4.70±2.75 | 2.89±2.12 | 7.25±3.14 | 0.001 † | | 0.046†† | 0.001†† |
| | $P_{within\ groups}$ | 0.071§ | 0.005§ | 0.48 | | | | |
| Soft tissue effects | | | | | | | | |
| Upper lip to E line (mm) | T1 | -1.58±3.07 | -3.06±2.87 | 0.17±2.88 | 0.037† | | | 0.013†† |
| | T2 | -2.01±2.38 | -4.02±2.53 | 0.23±2.64 | 0.001* | 0.034 ** | 0.035 ** | 0.000** |
| | $P_{within\ groups}$ | 0.509 | 0.097 | 0.861 | | | | |
| Lower lip to E line (mm) | T1 | -0.53±3.52 | -1.63±2.85 | 0.85±2.67 | 0.157 | | | |
| | T2 | -0.79±2.45 | -1.81±3.13 | 1.17±3.22 | 0.055 | | | |
| | $P_{within\ groups}$ | 0.654 | 0.742 | 0.589 | | | | |

SD indicates standard deviation. *$P$<0,05 for one way anova test, **$P$<0,05 for LSD test, †$P$<0,05 for Kruskal Wallis test, ††$P$<0,05 for all pairwise" multiple comparison test and §$P$<0,05 for paired samples $t$ test

**Table 2: Mean changes in each group and comparisons between groups for the cephalometric measurements**

| | TB (*n*=15) mean change±SD | FRD (*n*=15) mean change±SD | Control (*n*=10) mean change±SD | *P* | | | |
|---|---|---|---|---|---|---|---|
| | | | | All 3 groups | TB vs FRD | TB vs Control | FRD vs Control |
| Skeletal measurements | | | | | | | |
| SNA (°) | -1,98±2,33 | -1,1±2,16 | 0,03±1,96 | | | | |
| SNB (°) | -0,66±2,00 | 0,3±1,67 | 0,3±1,50 | | | | |
| ANB (°) | -1,29±1,30 | -1,42±1,68 | 0,07±1,06 | 0,029* | | 0,023** | 0,013** |
| GOGN-SN(°) | 1,29±2,14 | -1,01±2,78 | -1,12±2,18 | 0,014† | 0,018†† | 0,010†† | |
| SGO-NME% | -0,89±2,23 | 0,75±2,88 | 2,22±1,92 | 0,012* | | 0,003** | |
| Wits (mm) | -2,61±2,55 | -1,61±3,80 | -,28±1,24 | | | | |
| Co-A (mm) | 0,29±6,68 | 3,42±10,65 | -2,46±4,06 | | | | |
| Co-Gn (mm) | 6,33±7,04 | 9,20±11,77 | -3,64±6,04 | 0,002† | | 0,003†† | 0,001†† |
| Dental measurements | | | | | | | |
| U1-FH (°) | -4,75±7,53 | -0,09±10,06 | 1,71±4,35 | | | | |
| IMPA (°) | 3,25±6,31 | 6,91±6,17 | 0,75±2,30 | 0,014† | 0,029†† | | 0,007†† |
| Overbite (mm) | -0,03±1,98 | -1,79±1,37 | -0,43±1,20 | 0,023† | 0,014†† | | 0,029†† |
| Overjet (mm) | -3,35±2,30 | -2,89±2,00 | 0,13±1,03 | 0,000* | | 0,000** | 0,001** |
| Soft tissue measurements | | | | | | | |
| Upper lip to e line (mm) | -0,49±2,39 | -0,64±1,92 | 0,06±1,05 | | | | |
| Lower lip to e line (mm) | -0,27±2,20 | -0,49±2,11 | 0,32±1,81 | | | | |

SD indicates standard deviation. **P*<0,05 for one way anova test, ***P*<0,05 for LSD test, †*P*<0,05 for Kruskal Wallis test and ††*P*<0,05 for all pairwise" multiple comparison test

The intraclass correlation coefficient was used to test method error. The results were in the range of 0.91–0.98, which shows high-positive correlations, meaning the reliability of the measurements.

The cephalometric measurements for the dental, skeletal, and soft tissue changes in three groups at T1 and T2 and the *P* values are shown in Table 1.

The cephalometric changes in all three groups, the intergroup differences for changes, and the *P* values are shown in Table 2.

According to the results, there was no statistically significant difference for the initial values between the groups except upper lip to E line parameter ($P > 0.05$) [Table 1]. From the skeletal aspect, both treatment groups show a decrease in ANB angle with a consequent decrease in SNA angle in the TB group ($P < 0.05$) [Table 1]. TB produced a statistically significant increase in GOGN-SN angle compared with the FRD and controls ($P = 0.018$ and $P = 0.010$) [Table 2] with a statistically significant increase in SGO-NME angle compared with control group only ($P = 0{,}003$) [Table 2]. In both TB and FRD groups, increase in mandibular length (Co-Gn) was found to be statistically significant compared with the control group ($P = 0.003$ and $P = 0.001$, respectively) [Table 2]; however, the mean chance difference between two treatment groups was nonsignificant ($P > 0.05$) [Table 2]. Although there is no statistically significant difference in the mean changes of Wits values of any groups [Table 2]; in both treatment groups, a relatively normal Wits values have been measured at T2 time [Table 1].

Dental measurements show us that FRD produced a statistically significant mandibular incisor proclination compared with both TB and control groups ($P = 0.014$ and $P = 0.029$, respectively) [Table 2]. In accordance with this finding, again FRD shows a statistically significant opening of the bite compared with both TB and control groups ($P = 0.029$ and $P = 0.007$, respectively) [Table 2]. A very highly statistically significant difference was seen in TB, which shows a decrease in the amount of overjet compared with the FRD and control group ($P \leq 0.001$).

There is no statistically significant difference found between mean changes of any groups from the aspect of soft tissue measurements.

## Discussion

Class II malocclusions characterized in part by mandibular skeletal retrusion can be treated with removable or fixed functional orthodontic appliances. When choosing the type of the appliance, the most important parameter is the maturation level of the patient.

This study analyzed the treatment effects of the TB appliance, which is generally better tolerated by patients,[2,3] as it is smaller than other functional appliances and less interference with speech and FRD, which is a very popular fixed functional appliance used by clinicians nowadays, during a mosaic of peak and postpeak growth periods. Baccetti *et al*.[6] evaluated the effects of TB appliance in both early (before the peak) and late (during or slightly after the onset of the pubertal growth spurt) treatment groups and reported a greater skeletal contribution to molar correction, larger increments in total mandibular length and in ramus height, and more posterior direction of condylar growth in late treatment group. Similarly, O'Brien *et al*.[7] demonstrated that early treatment with the TB appliance is effective in reducing overjet and severity of malocclusion, but the small change in the skeletal relationship might not be considered clinically significant. In a cone-beam computed tomography study evaluating the condylar changes in patients treated with TB, it was reported that TB increases condylar volume, mandibular length, and intercondylar distance by stimulating growth of condyle in an upward and backward direction in a similar age group[12] (male subjects with mean age of 12.83 years and 14 female subjects with mean age of 12.5) with this study. In another study Aras *et al*.[13] who compared the treatment outcomes of FRD between peak pubertal group and late pubertal group reported that dental changes were practically the same in adolescents at the peak of puberty and in late puberty; but in the late adolescents, no significant changes were observed in mandibular dimensions. Accordingly, Franchi *et al*.[14] compared the treatment outcomes of FRD (mean age 12.7 ± 1.2 years) with a control group of untreated ones and concluded that the FRD protocol is effective in correcting Class II malocclusion with a combination of skeletal (mainly maxillary) and dentoalveolar (mainly mandibular) modifications. Together with these findings, it can be said that the sample collection for both TB and FRD treatments are fit for the purpose about the best treatment timing for TB or FRD usage in order to see both dental and skeletal effects of the appliances and compare each other.

In the literature, there are three studies comparing the effects of TB and FRD with respect to an untreated Class II control sample[15-17] The most apparent difference of this research from the previous ones is the timing of the cephalometric records used to compare the dental, skeletal, and soft tissue effects of two functional appliances. In this study, cephalometric records which were taken just before the insertion of FRD were used as pretreatment and the ones which were taken just after the removal of FRD used as posttreatment records. Unlike us, Mahamad *et al*.,[17] Giuntini *et al*.,[15] and Hanoun *et al*.[16] used the records before orthodontic bonding procedure as pretreatment records in FRD group. Moreover, Giuntini *et al*.[15] used the debonding records taken after comprehensive fixed treatment fallowing TB usage as the posttreatment records of TB group. During the leveling phase of orthodontic treatment, dentoalveolar changes are inevitable. At the same time, the elastic usage in the finishing phase of orthodontic treatment also can come out with undesirable dental changes. The reason for usage of a design like in this study is the fact that records taken just before the insertion and just after the removal of FRD or TB gives the opportunity for investigating the pure appliance effect on dentoskeletal structure.

## Comparison of treatment changes

### *Skeletal effects*

The maxillary changes accounted for significant improvements in maxillo-mandibular sagittal relationships that ranged from 1.29 for the ANB angle and 2.61 mm for the Wits appraisal in TB and 1.42° for the ANB angle and 1.61 mm for the Wits appraisal in FRD group with a statistically significant decrease in SNA angle for TB group. The ANB angle can be affected by several factors, including growth rotations of the jaws and vertical growth due to changes in the distance between points A and B and points N and B.[18] Although both TB and FDR shows a significantly greater increase in mandibular length mean differences than the control, only FRD demonstrated a significant difference than the control at the end of the treatment period. It can be said that rather than a maxillary restriction, mandibular growth was the reason for the Class II correction for FRD group of patients. TB in contrast, shows a significant restriction in maxilla together with an increase in mandibular length, which means us that the mixture of these effects is the reason for Class II correction. Not similar to our findings, studies reporting no SNA difference in TB or FRD groups attribute this finding to the effects of the changes in the incisor root apices that may retrusion A point.[17,19,20]

Accept a little increase in FRD group; all groups exhibited very similar characteristics in terms of responsiveness to mandibular growth stimulation, as assessed by the pretreatment GOGN-SN angle. They demonstrated a prevalence rate of good responders (GOGN-SN angle between 32 ± 5). But according to the comparison of mean changes between groups, TB induced a significant posterior rotation of the mandible with respect to the both FRD and control sample. Also, this result is supported by the increase in the posterior/anterior facial ratios in TB group. Our results are incompatible with the findings of Lund and Sandler[4] and Mills and McCulloch[5] who were reported that the mandibular plane angle in their studies did not change with treatment as both anterior and posterior facial heights increased in TB groups, but compatible with the findings of another study[15] which reported a significant posterior rotation of the mandible in TB group. According to our results, FRD did not show any significant difference from control as mentioned by some investigators before.[14,15,21]

### *Dental effects*

Both treatment regimens proved to be effective on occlusal parameters. A net reduction of 3.35 mm in TB and 2.89 mm in FRD was recorded for the overjet. Both treatment groups showed more mandibular incisor proclination compared with control, but only FRD group had a significantly higher mandibular incisor proclination than the others. Also, upper incisor retroclination is significantly higher in TB than FRD and control. In the light of these findings, it can be said that the dental correction of the overjet in TB group is due to both upper incisor retroclination and lower incisor proclination, but in FRD group, it is due mainly to lower incisor proclination. Our findings are in accordance with the others about the upper incisor retrusion in TB,[3,5,6,22] and lower incisor proclination in FRD.[14,15,17] Nowadays, one regimen developed to prevent lower incisor proclination is the usage of skeletal anchorage in mandible. In the literature, there are examples of usage of mini screws in premolar area[19] or mini plates in canine area[23] in order to hinder incisor proclination, which promises a less side effects of fixed functional treatments.

### *Soft tissue effects*

Although there is a slight retrusion of the upper lip, there is no statistically significant soft tissue change found in the measured parameters in this study. Our findings of soft tissue changes confirm with the result of the others.[10,24] The slight retrusion of the upper lip could be perhaps explained by the retraction of upper lip as a result of upper incisor retroclination.

## Conclusions

1. Both TB and FRD were effective in correction of the Class II malocclusion by some dental and some skeletal changes in this period of growth groups
2. Both TB and FRD enhance mandibular growth, but only TB restrict maxillary growth
3. Overjet correction was made by a more dental correction in FRD with an unwanted amount of mandibular proclination
4. Although TB and FRD produce some changes in the soft tissue, the magnitude of the changes may not be perceived as clinically significant
5. The unique timing of the cephalometric records used in this study seems to not make a significant difference.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

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