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Pretreatment Factors Associated With Response to Eruption Guidance Appliance Therapy in Class II Division 1 Malocclusion: A Preliminary Pilot Study

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Fouzi Boukhazani [1]

1. Orthodontics and Dentofacial Orthopedics, University of Algiers Benyoucef Benkhedda, Algiers, DZA

Corresponding author: Fouzi Boukhazani, fboukhazani2025@gmail.com

Abstract

Purpose

The purpose of this study is to identify pretreatment factors associated with response to eruption guidance appliance (EGA) therapy in growing patients with Class II Division 1 malocclusion.

Methods

A retrospective cephalometric study was conducted on 12 growing patients treated with a Multi-P eruption guidance appliance. Standardized lateral cephalograms obtained before treatment (T1) and after treatment (T2) were analyzed. Simple linear regression analyses were performed to investigate the association between pretreatment demographic, cephalometric, and occlusal variables and improvement in the A point-nasion-B point (ANB) angle.

Results

Younger age at treatment initiation demonstrated the strongest association with ANB angle improvement (R^2=0.556; p=0.005). In addition, greater pretreatment overjet (R^2=0.492; p=0.011), a higher Jarabak ratio (R^2=0.459; p=0.015), a lower Y/SN angle (R^2=0.445; p=0.018), and a higher sella-nasion-A point (SNA) angle (R^2=0.335; p=0.048) were also significantly associated with greater sagittal improvement. Conversely, pretreatment ANB, pretreatment sella-nasion-B point (SNB), overbite, and treatment duration were not significantly associated with treatment response.

Conclusion

Pretreatment age, craniofacial morphology, and overjet were associated with response to EGA therapy in growing patients with Class II Division 1 malocclusion. These findings may help clinicians identify patients more likely to benefit from interceptive orthodontics and support individualized treatment planning. Further prospective studies with larger samples are required to confirm these findings.

Categories: Dentistry
Keywords: class ii division 1 malocclusion, functional orthodontic appliances, guidance of eruption, interceptive orthodontics, lateral cephalometry

Introduction

Class II Division 1 malocclusion is one of the most prevalent orthodontic conditions in growing children, with reported frequencies ranging from 15% to 30% [1,2]. It is characterized by an increased overjet associated with varying degrees of skeletal and dentoalveolar discrepancy and may adversely affect facial aesthetics, oral function, and psychosocial well-being. Interceptive treatment is frequently indicated to reduce overjet, improve sagittal skeletal relationships, and reduce the risk of maxillary incisor trauma [1,3].

Among the available interceptive approaches, eruption guidance appliances (EGAs) offer a simple treatment option that combines dentoalveolar guidance with functional stimulation during mixed dentition. Previous clinical studies have reported favorable treatment effects, including reductions in overjet and improvements in Class II relationships [4,5]. More broadly, prefabricated functional appliances have been shown to produce favorable skeletal and dentoalveolar improvements in growing patients with Class II Division 1 malocclusion, comparable to those achieved with conventional functional appliances [6].

Despite these reported treatment effects, outcomes following EGA therapy remain variable. While some patients demonstrate substantial skeletal and dentoalveolar improvements, others exhibit more limited changes, suggesting that individual pretreatment characteristics may influence treatment response.

However, evidence specifically concerning EGAs remains limited, and little is known about the demographic, cephalometric, and occlusal characteristics present before treatment that may be associated with subsequent outcomes.

Therefore, the aim of the present retrospective pilot study was to identify pretreatment factors associated with sagittal skeletal response to eruption guidance appliance (EGA) therapy, as assessed by changes in the A point-nasion-B point (ANB) angle, in growing patients with Class II Division 1 malocclusion.

Materials And Methods

Study design

This pilot cephalometric study investigated pretreatment factors associated with treatment response to EGA therapy in growing patients with Class II Division 1 malocclusion. Clinical records and lateral cephalograms obtained during routine orthodontic care between 2015 and 2025 at the Department of Orthodontics of Algiers University of Health Sciences Hospital were retrospectively reviewed. Treatment had been completed before the study was conceived, and no patient was recruited specifically for research purposes.

Patient selection

Patients were eligible for inclusion if they presented with Class II Division 1 malocclusion, were aged between 8 and 12 years at treatment initiation, and were treated with the same preformed eruption guidance appliance model (Multi-P, low version, RMO, Denver, CO). Additionally, inclusion required the availability of standardized lateral cephalograms taken both before treatment (T1) and upon the completion of therapy (T2), along with complete clinical records.

Patients presenting with craniofacial syndromes, intellectual disability, dental agenesis, impacted teeth, transpositions, or severe dentoalveolar discrepancies requiring additional treatment were excluded.

Fourteen files fulfilled the initial inclusion criteria. Two patients were subsequently excluded because of incomplete records, resulting in a final sample of 12 patients.

Treatment protocol

All patients were treated using the same preformed EGA (Multi-P, low version, RMO, Denver, CO). Patients were instructed to wear the appliance throughout the night and approximately four hours during the day.

Patient compliance was monitored throughout the treatment period using specific weekly compliance forms completed by the parents. These forms recorded the reported duration of appliance wear during daytime and nighttime. At each follow-up appointment, the previously completed form was reviewed, and a new form was provided for the subsequent monitoring period.

The same appliance was used throughout the treatment during the observation period. Treatment duration ranged from 7 to 16 months.

Cephalometric analysis

Standardized lateral cephalograms were obtained before treatment (T1) and immediately after the completion of EGA therapy (T2).

Cephalometric analyses were performed using WeDoCeph software (Audax d.o.o., Ljubljana, Slovenia). Clinical features were not incorporated into the software-based tracing process. All landmarks were verified by the investigator, and measurements were checked before statistical analysis.

Because radiographs originated from different radiographic units, only angular measurements and proportional indices were analyzed to minimize the influence of radiographic magnification. Linear measurements were therefore intentionally excluded.

The primary outcome was the change in the ANB angle (ΔANB), which was considered to represent improvement in sagittal skeletal discrepancy.

The potential pretreatment factors evaluated for their association with treatment response included age at treatment initiation, sex, treatment duration, overjet, overbite, and vertical skeletal parameters. Cephalometric evaluation encompassed both sagittal and vertical skeletal morphology measured at baseline (T1) and post-treatment (T2).

Sagittal skeletal relationships were assessed using the sella-nasion-A point (SNA) angle, which indicates the anteroposterior position of the maxilla relative to the cranial base; the sella-nasion-B point (SNB) angle, representing the sagittal position of the mandible; and the A point-nasion-B point (ANB) angle, quantifying

the intermaxillary sagittal discrepancy.

Vertical facial skeletal morphology was evaluated using the Jarabak ratio, calculated as the ratio of posterior to anterior facial height (S-Go/N-Me×100); the Y-axis to sella-nasion line angle (Y/SN), assessing the directional pattern of facial growth; and the gonial angle (Ar-Go-Me), representing mandibular morphology.

Additionally, changes in selected cephalometric variables during therapy were explored to refine the overall interpretation of treatment effects.

Statistical analyses

Statistical analyses were performed using Epi Info version 7.2 (CDC, Atlanta, GA) and Microsoft Excel (Microsoft Corporation, Redmond, WA).

Descriptive statistics were calculated for all variables.

Simple linear regression analyses were performed to investigate the association between each pretreatment variable and treatment response, expressed as the change in ANB angle. Regression coefficients, coefficients of determination R^2, 95% confidence intervals, and corresponding p-values were calculated.

Variables demonstrating significant associations in the univariable analyses were subsequently entered into an exploratory multiple linear regression model to assess their combined relationship with treatment response. Owing to the limited sample size, this multivariable analysis was considered exploratory. Statistical significance was set at $p<0.05$.

Ethics

This retrospective study was considered using anonymized clinical records and radiographs collected during routine orthodontic care. No patient was recruited specifically for research purposes, and all treatment decisions were made independently of the present study. Written informed consent authorizing the use of anonymized clinical data for research purposes had been obtained from all the legal guardians of patients before treatment. All data were anonymized prior to analysis, and patient confidentiality was strictly maintained throughout the study.

Results

Patient characteristics

Twelve growing patients (six females and six males) fulfilled the inclusion criteria and were included in the final analyses. The mean age at treatment initiation was 9.6±1.6 years. The mean duration of EGA therapy was 11.5±3.5 months.

Baseline cephalometric and occlusal characteristics are represented in Table *1*.

Characteristic	Mean	SD
Age (years)	9.6	1.6
Treatment duration (months)	11.5	3.5
Overjet	3.83	1.99
Overbite	2.41	1.50
SNA (°)	83.35	5.37
SNB (°)	76.59	4.59
ANB (°)	6.3	2.14
Jarabak ratio (%)	61	3.92
Y/SN (°)	70.41	4.67
Gonial angle (°)	127.8	4.49

TABLE 1: Baseline demographic, treatment, and cephalometric characteristics of the study sample (n=12)

SNA, sella-nasion-A point; SNB, sella-nasion-B point; ANB, A point-nasion-B point

Treatment response

The mean improvement in the ANB angle following EGA therapy was 1.45°±1.50°. Considerable inter-individual variability in treatment response was observed.

Association between pretreatment factors and treatment response

Simple linear regression analyses demonstrated that younger age at treatment initiation showed the strongest association with improvement in the ANB angle (R^2=0.557; p<0.005) (Figure *1*).

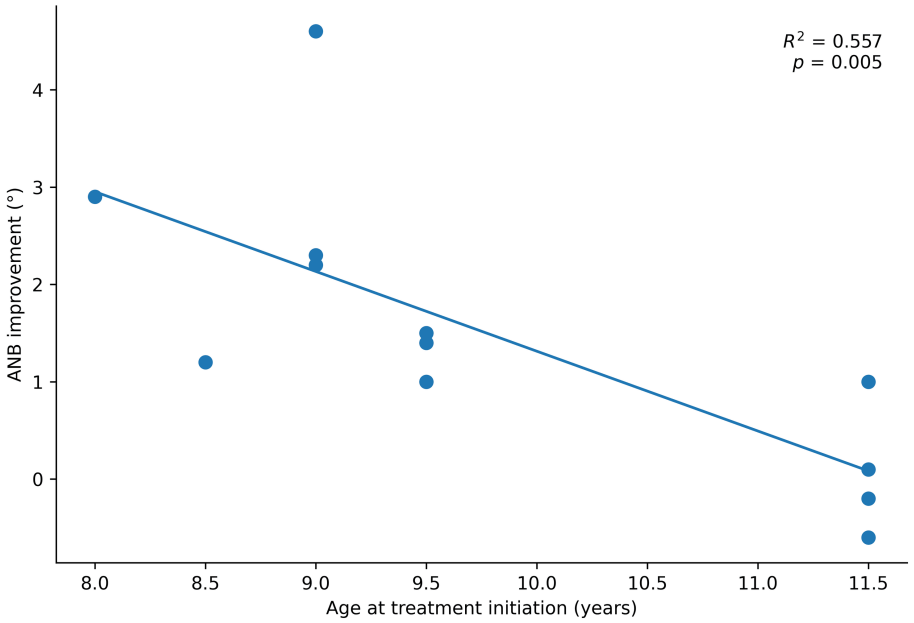


FIGURE 1: Association between age at treatment initiation and ANB improvement (n=12)

The solid line represents the fitted linear regression (R^2=0.557; p=0.005)

ANB: A point-nasion-B point

Among the cephalometric variables, a higher pretreatment Jarabak ratio (R^2=0.459; p=0.015), a lower Y/SN angle (R^2=0.445; p=0.018), and a higher SNA angle (R^2=0.335; p=0.048) were significantly associated with greater improvement in the ANB angle (Figure 2).

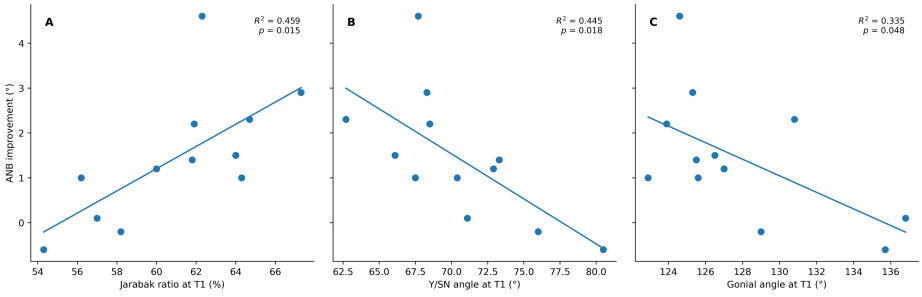


FIGURE 2: Associations between pretreatment vertical craniofacial characteristics and ANB improvement: (A) Jarabak ratio, (B) Y/SN angle, and (C) gonial angle (n=12)

Solid lines represent the fitted linear regressions

ANB: A point-nasion-B point

Regarding occlusal characteristics, greater pretreatment overjet was significantly associated with greater ANB improvement (R^2=0.492; p=0.011), whereas pretreatment overbite showed no significant association (p=0.568).

Neither pretreatment ANB (p=0.885), pretreatment SNB (p=0.102), nor treatment duration was significantly associated with treatment response.

The studied associations with ANB improvement are summarized in Table 2.

Pretreatment factor	Regression coefficient (B)	95% CI	R^2	P-value
Age	-0.819	-1.335 to -0.304	0.556	0.005
Treatment duration (months)	-0.044	-0.329 to 0.239	0.012	0.734
Overjet	0.504	0.143 to 0.865	0.492	0.011
Overbite	-0.175	-0.484 to 0.833	0.034	0.568
SNA (°)	0.158	0.007 to 0.309	0.335	0.041
SNB (°)	0.154	-0.037 to 0.345	0.245	0.102
ANB (°)	-0.039	-0.510 to 0.431	0.003	0.855
Jarabak ratio (%)	0.247	0.058 to 0.436	0.459	0.015
Y/SN (°)	-0.200	-0.358 to -0.043	0.445	0.018
Gonial angle (°)	-0.184	-0.367 to -0.002	0.335	0.048

TABLE 2: Univariable linear regression analyses of pretreatment factors associated with ANB improvement

Note: n=12 for all univariate simple linear regression analyses. The dependent variable was ANB angle improvement (ΔANB), calculated as the pretreatment ANB angle (T1) minus the post-treatment ANB angle (T2). B represents the unstandardized regression coefficient, CI indicates the 95% confidence interval, and the coefficient of determination (R2) represents the proportion of variance in ANB angle improvement explained by each pretreatment variable

SNA, sella-nasion-A point; SNB, sella-nasion-B point; ANB, A point-nasion-B point; CI, confidence interval

Exploratory multiple regression analysis

In an exploratory multivariable linear regression model including age, Jarabak ratio, and pretreatment overjet, the overall model was significant (R^2=0.776; adjusted R^2=0.692; F(3,8)=9.23; p=0.006). Pretreatment overjet remained independently associated with ANB improvement (B=0.384; 95% CI: 0.063-0.705; p=0.025), whereas age (p=0.667) and Jarabak ratio (p=0.252) were no longer statistically significant.

Discussion

The present pilot study investigated pretreatment factors associated with response to EGA therapy in growing patients presenting with Class II Division 1 malocclusion. The findings demonstrated considerable inter-individual variability in treatment response and identified several pretreatment characteristics associated with greater improvement in sagittal skeletal relationships. Younger age at treatment initiation showed the strongest association with ANB improvement, while favorable vertical craniofacial morphology, characterized by a higher Jarabak ratio, a lower Y/SN angle, and a lower gonial angle, as well as greater pretreatment overjet, was also significantly associated with treatment response. In contrast, pretreatment ANB, pretreatment SNB, overbite, and treatment duration were not significantly associated with the magnitude of ANB improvement. Collectively, these findings suggest that treatment response to EGA therapy is influenced more by patient growth potential and craniofacial morphology than by the initial severity of the sagittal skeletal discrepancy.

Recently, systematic reviews have confirmed that EGAs can produce significant improvements in occlusal and cephalometric outcomes, although the available evidence remains limited by the small number of controlled studies and the heterogeneity of treatment protocols [7,8]. However, little attention has been paid to the identification of pretreatment characteristics associated with individual response to EGA therapy. Consequently, the direct comparison of the actual findings with the previous EGA studies is limited, as most investigations have focused on mean treatment effects rather than the factors influencing the individual response.

The strongest association identified in the present study was between younger age at treatment initiation and greater improvement in the ANB angle. A possible explanation for the present findings is therefore that younger patients were treated during a biologically more responsive stage of dentoalveolar development, when active tooth eruption and alveolar bone remodelling may facilitate the therapeutic effects of eruption guidance appliances. As eruption approaches completion during late mixed dentition, the capacity for dentoalveolar adaptation may progressively decline, potentially reducing treatment responsiveness. This hypothesis is consistent with recent systematic reviews confirming the clinical effectiveness of eruption

guidance appliances while highlighting the limited understanding of the biological mechanisms underlying inter-individual variability in treatment response [7]. Recent systematic evidence confirms that orthopedic correction in growing Class II patients typically reflects a combined expression of mandibular advancement and dentoalveolar remodelling rather than isolated skeletal change [9].

Unlike conventional functional appliances, eruption guidance appliances are specifically intended for use during the mixed dentition, when tooth eruption, occlusal development, and dentoalveolar adaptation occur simultaneously [5,10]. Tooth eruption is now recognized as a highly coordinated biological process involving the continuous remodelling of the alveolar bone, periodontal ligament adaptation, and interactions between the dental follicle and surrounding bone [11]. Experimental studies have demonstrated that active alveolar bone remodelling accompanies tooth eruption, with intense osteoblastic activity mediated by signalling pathways including BMP6, BMP2, and BMP7 [12]. Furthermore, structural studies have shown that the alveolar bone adjacent to erupting teeth remains highly dynamic until functional occlusion is established, undergoing progressive maturation and reinforcement throughout the eruption process [13].

Interestingly, age was not the only pretreatment characteristic associated with treatment response. Beyond treatment timing, several cephalometric variables describing craniofacial morphology were also significantly associated with ANB improvement. This observation suggests that the response to EGA therapy is unlikely to depend on a single biological factor. Instead, it probably results from the interaction between the developmental stage of the patient and the underlying craniofacial phenotype.

One of the most consistent findings was the association between pretreatment vertical craniofacial morphology and ANB improvement.

Patients with a higher Jarabak ratio, a lower Y/SN angle, and a lower gonial angle exhibited greater improvement in the ANB angle following EGA therapy. Although these variables describe different cephalometric measurements, they collectively characterize a less hyperdivergent craniofacial pattern, with greater posterior facial height, a more favorable mandibular rotational pattern, and increased vertical skeletal stability [1,14].

The present findings are in close agreement with those reported by Kumar et al., who specifically investigated pretreatment cephalometric predictors of successful response to functional appliance therapy [15]. Using improvement in the ANB angle as the primary outcome, they found that patients presenting with a high Jarabak ratio, low mandibular plane angle, and low basal plane angle achieved significantly greater skeletal correction following treatment.

From a biological perspective, a less hyperdivergent facial pattern is generally associated with more favorable mandibular rotation, greater posterior facial support, and increased masticatory muscle efficiency, all of which may contribute to improved sagittal adaptation during growth. In growing Class II Division 1 subjects, significant reductions in the ANB angle following functional orthopedic therapy are closely tied to the degree of sagittal mandibular advancement achieved relative to dentoalveolar compensation [16].

Another clinically relevant finding was the significant association between pretreatment overjet and treatment response. One possible explanation is that increased overjet identifies patients whose sagittal discrepancy remains highly responsive to dentoalveolar adaptation during the mixed dentition. Alternatively, greater overjet may simply provide a larger therapeutic potential for correction. Pretreatment overjet has previously been considered among the clinical and cephalometric characteristics potentially influencing the outcome of functional appliance treatment in Class II Division 1 malocclusion, although substantial inter-individual variability remains and no single pretreatment characteristic has consistently predicted treatment response [17,18].

Pretreatment ANB and SNB were not significantly associated with treatment response, whereas a higher pretreatment SNA was associated with greater ANB improvement. This should nevertheless be interpreted cautiously. Given the small sample size, it may represent one component of a broader craniofacial phenotype rather than an independent determinant of treatment response.

From a clinical perspective, these findings suggest that treatment response cannot be inferred from a single pretreatment measurement. Rather, younger age, favorable vertical craniofacial morphology, and increased overjet may collectively characterize patients with greater potential for sagittal improvement during EGA therapy. These characteristics are readily available during routine orthodontic assessment and may therefore contribute to case selection and treatment timing. However, given the exploratory nature of the present study, they should be regarded as factors associated with response rather than as clinical predictors or selection criteria.

When age, Jarabak ratio, and pretreatment overjet were considered simultaneously, pretreatment overjet retained the strongest independent association with ANB improvement. The attenuation of the associations with age and Jarabak ratio may reflect the interrelationship between developmental stage, craniofacial morphology, and occlusal characteristics. This interpretation is consistent with previous evidence

suggesting that functional appliance response results from the interaction of several patient-related and morphological characteristics rather than from a single determinant [19,20]. Given the small sample size, however, the present multivariable analysis should be considered exploratory rather than predictive.

Several limitations should be considered when interpreting the findings of this study. First, the retrospective design and small sample size (n=12) limit statistical power, generalizability, and the ability to account for potential confounding factors. Furthermore, the retrospective selection of eligible patient records may have introduced selection bias. The absence of an untreated Class II control group prevents the effects potentially associated with eruption guidance appliance (EGA) therapy from being distinguished from changes attributable to normal craniofacial growth. Accordingly, the observed changes and associations should be interpreted as exploratory rather than causal.

Second, the multivariable linear regression model included three explanatory variables despite the limited sample size. This raises a substantial risk of overfitting and limits the stability and reliability of the estimated associations. Therefore, the finding that pretreatment overjet remained significantly associated with ANB reduction should be interpreted cautiously and should not be considered evidence of a robust, independently validated predictor. The results are hypothesis-generating and do not support the development of a definitive predictive model.

Third, treatment response was assessed primarily through changes in the ANB angle, which reflects the sagittal relationship between the maxilla and mandible but does not independently quantify mandibular advancement. The absence of complementary linear skeletal measurements and dental angular measurements prevented us from distinguishing the respective contributions of skeletal changes, including maxillary or mandibular positional changes, and dentoalveolar compensation. Consequently, the observed ANB reduction cannot be attributed exclusively to skeletal improvement.

Fourth, each cephalogram was traced once using WeDoCeph software, and no formal method-error analysis, such as Dahlberg's formula or intraclass correlation coefficients, was performed. Although clinical features were not incorporated into the software-based tracing process, no formal operator-blinding protocol was implemented; therefore, measurement bias cannot be entirely excluded.

Fifth, patient compliance was monitored throughout treatment using weekly forms completed by parents, documenting reported daytime and nighttime appliance-wear hours. However, compliance was based on parental reports rather than objective measurement, and the recorded wear duration may not fully reflect actual appliance use.

Finally, although the radiographs were intended to be obtained at real size, no formal magnification calibration protocol across the different radiographic machines was documented. The decision to exclude linear measurements reduced the potential impact of magnification discrepancies on linear measurements; however, the absence of these measurements also limited the assessment of dimensional skeletal and dentoalveolar changes. Although uniform magnification does not directly affect angular measurements such as the ANB angle, potential differences in image acquisition cannot be entirely excluded.

Overall, these methodological limitations emphasize the preliminary nature of the findings. Larger prospective studies with appropriate untreated comparison groups, standardized radiographic protocols, formal assessments of measurement reliability, and complementary linear and angular measurements are needed to distinguish treatment-associated changes from normal growth, better characterize skeletal and dentoalveolar adaptations, and validate potential predictors of response to EGA therapy.

Future prospective studies should give particular attention to the relationship between active tooth eruption, alveolar remodelling, and treatment timing. Such investigations could determine whether the favorable response observed at younger ages reflects a specific biological window for eruption guidance therapy and ultimately contribute to more individualized patient selection.

Conclusions

In this pilot study, response to eruption guidance appliance therapy in growing patients with Class II Division 1 malocclusion was associated with several pretreatment characteristics. Younger age, a favorable vertical craniofacial pattern, and greater pretreatment overjet were associated with greater improvement in sagittal skeletal relationships. These findings suggest that developmental timing and craniofacial morphology may contribute to individual variability in treatment response. However, given the limited sample size, these characteristics should be considered associated factors rather than predictors of treatment outcome.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the

work.

Concept and design: Fouzi Boukhazani

Acquisition, analysis, or interpretation of data: Fouzi Boukhazani

Drafting of the manuscript: Fouzi Boukhazani

Critical review of the manuscript for important intellectual content: Fouzi Boukhazani

Supervision: Fouzi Boukhazani

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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