EFFICIENCY AND EFFECTIVENESS OF SURESMILE

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Aim: *To examine the efficiency and effectiveness of the SureSmile process using the standards of the American Board of Orthodontists Objective Grading System (ABO OGS).* ***Methods:*** *Three diplomates of the American Board of Orthodontics provided study casts of 62 patients whose orthodontic treatment was consecutively completed. Patients treated using the SureSmile process and a conventional approach were anonymized and randomized prior to independent scoring by two ABO OGS–calibrated examiners.* ***Results:*** *Intra- and interexaminer reliability was consistent in all components with no differences between examiners ($r = 0.96$, $P < .001$). The ABO OGS score for the SureSmile patients (mean 26.3) was 4.4 points lower ($P < .001$) than for those treated conventionally (mean 30.7). Furthermore, treatment with the SureSmile process was shorter (14.7 months vs 20.0 months).* ***Conclusion:*** *The SureSmile process results in a lower mean ABO OGS score and a reduced treatment time than conventional approaches. The approach has great potential to both decrease treatment time and improve quality.* World J Orthod 2010;11:16–22.

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Efficient management of orthodontic patients in delivering timely care is an important aspect of treatment.[1] Orthodontics is focused on developing methods or techniques to decrease treatment time while maintaining quality outcomes. Although orthodontists have pursued this goal for quite some time, at present, there is no conventional orthodontic biomechanical treatment approach that has demonstrated any greater efficiency or effectiveness than any other. This is likely due to the complexity of orthodontics and the diversity of patients. Thus, it is imperative to understand the factors that can adversely impact the length of orthodontic treatment and use this information to implement measures that promote care more predictably and timely.

Studies have shown that average treatment time ranges from 23.1 to 31.2 months, depending on the design of the investigation and other factors.[1,2] A study from New Zealand determined average treatment length to be 23.5 months with a range of 12.0 to 37.0 months (SD 4.7, n = 366),[3] similar to the previously reported 23.1 months[2] and 22.0[4] months from a comparable study. However, longer treatment times (28.6 months[5] and 31.2 months[1]) are also found in the relevant literature.

Patient cooperation is well-recognized as a factor of treatment duration. It encompasses missed appointments, compliance with appliance wear, broken appliances, and poor oral hygiene. The role of poor patient cooperation on treatment length has been described in a number of studies.[2,3,5–8] Regardless of patient age, 46% of the variability in treatment duration and 24% of the variability in treatment effectiveness was explained by the number of missed appointments and broken appliances.[6] Poor elastic wear was shown to increase treatment length by a mean of 1.4 months, while three or more poor oral hygiene entries increased treatment time by 1.2 months.[3] Similar findings of the effect of patient cooperation on treatment time have been reported.[9,10]

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Malocclusion severity is another major factor that influences treatment duration. It was significantly longer for patients with a discrepancy index (DI) score greater than 20 (32.9 months) compared to those with a DI score between 10 and 19 (28.5 months) or less than 10 (26.3 months).[11,12] Other studies have shown that the Angle Class and magnitude of overjet have an impact on treatment length. Correction of Class II relationships took 5 months longer than Class I occlusions.[13] The severity of overjet was found to explain 46% of the variability in treatment duration.[7] Similarly, the pretreatment Peer-Assessment Rating (PAR) Index[14] was higher in patients with a Class II occlusion compared to those with a Class I relationship, reinforcing that it takes a certain amount of time to correct the buccal occlusion and overjet.[7,15] However, there is one study that denies a relationship between the severity of malocclusions and treatment duration.[16] No differences in treatment duration or number of appointments were found between Class 1 and Class 2 nonextraction/extraction patients.[17] Finally, one study saw no significant association between the magnitude of the overbite and overjet with treatment duration.[18]

Further, extraction has been considered a factor that increases treatment duration.[2,4,8,13,15] This is particularly true for premolar extractions, which could extend treatment by 4.6 months compared to nonextraction orthodontic therapy.[4] Altering the course of treatment from the original plan, often referred to as trial nonextraction therapy, was also found to be a significant cause of increased treatment time.[9] However, there are again studies that reported that extractions do not significantly affect the length of treatment.[5,10]

Treatment quality is another factor that affects treatment duration. A good number of measures have been developed to objectively determine the quality of orthodontic treatment. One example is the Objective Grading System (OGS), which was developed by the American Board of Orthodontics (ABO). It was designed by a committee in 1994 with the goal of establishing a more objective evaluation. Beginning in 1995, it was revised over the course of four field tests. In February 1999, the ABO officially implemented this grading system for the assessment of completed orthodontic therapies.[19]

The reliability of the ABO OGS has been studied by four orthodontic faculty members who assessed 36 randomly selected posttreatment study models gathered from six orthodontic offices.[20] Intraexaminer differences were found to range from three to six subtraction points in the total score (r = 0.77) between two grading sessions. The correlation was greatest for occlusal relationships (r = 0.83) and least for interproximal contacts (r = 0.52). The interexaminer correlation coefficient for the total ABO OGS score was also good (r = 0.85), with the greatest correlation for buccolingual inclination (r = 0.85) and lowest for overjet (r = 0.50). The data revealed that some judges were much more lenient than others, which resulted in a wide range of total scores (19.7 to 27.5). Most deductions were found in the buccal segments and related to the second molars. This study suggests that the reliability and objectiveness of the ABO OGS are not absolute but render the index highly valuable.

Severity of the initial malocclusion is an important factor in establishing treatment complexity. Thus, in 1999, the ABO began developing a method to measure the level of treatment difficulty to determine the acceptability of patients submitted for Phase III of the ABO OGS certification. As a result, the DI was developed as an objective measure of the pretreatment malocclusion. After 5 years of development and field testing, the DI has replaced the case category requirements previously used as guidelines for submissions.[19]

Both the ABO OGS and the DI have been compared in one study to the PAR index and the comprehensive clinical assessment (CCA); 126 pre- and posttreatment records were therefore examined.[21] There was no correlation between the pretreatment PAR and the DI (with cephalometric values) or between the posttreatment PAR and ABO OGS. However, there was a statistically significant correlation (r = 0.67, P < .0001) between the PAR weighted scores and the DI when its cephalometric values were deleted. Both the PAR and the DI were determined to be useful indexes for evaluating malocclusion severity and treatment difficulty.[21]

Another major factor influencing both treatment duration and quality is the biomechanical therapy plan. Recently, a novel computer-assisted approach has been introduced.[22] The SureSmile process (OraMetrix) begins with a direct 3D scan of the patient's dentition using an intraoral camera that produces images to create a computer model of the dentition. Various treatment simulations can be performed, and the chosen approach of therapy is used to design and create wires with a bending robot. The deviations of the bends and torques in stainless steel wires are less than 1 degree.[23]

The impact of this system on orthodontic treatment and its duration had yet to be evaluated. Therefore, it was the objective of this study to examine the efficiency and effectiveness of the OraMetrix SureSmile system compared to conventional orthodontic treatment techniques. The hypothesis was that there is a significant difference ($P < .05$) between the OGS scores of the completed SureSmile patients and patients treated by conventional methods.

MATERIALS AND METHODS

The authors collected the pre- and posttreatment study models of the 62 most recent consecutively completed SureSmile and conventionally treated patients. The pretreatment models were used to determine the DI score and the posttreatment ones to define the OGS score. Treatment length was determined as the time from bonding to debonding. Exclusion criteria were incomplete casts; articulator-mounted casts; or casts from patients with missing molars, orthognathic surgery, or prosthodontic restorations.

Before any scoring, the patients treated with the SureSmile finishing wire (n = 38) and those treated traditionally (n = 24) were anonymized and randomized. Two independent calibrated examiners (graders) evaluated each model. Statistical analysis was conducted using the paired sample *t* test, the results of which established the intra- and interexaminer reliability.

The examiners were calibrated using standardized models, the ABO OGS measuring gauge, and the guidelines provided by the ABO OGS.[19] After scoring of each model, the results were reviewed both separately and jointly. Cephalometric values and root parallelism were not appraised as part of the DI in this study. The congruent categories were then scored again on the posttreatment models using the ABO OGS.

RESULTS

Data collection analysis

First to be tested using standard diagnostic statistics was whether the data collected by each grader was approximately normally distributed. The distributions had only a slight skew and no kurtosis. This indicated that the data were approximately normally distributed and to be tested with parametric statistical tests.

The mean values for all ABO OGS scores for both examiners are listed in Table 1. Mean value for grader 1 was 27.3 (SD = 7.8) and 28.7 (SD = 8.1) for grader 2. The standard error of the mean (SE), a statistic more appropriate than standard deviation for comparing relatively small samples, was low for the two graders (0.99 and 1.03, respectively) and essentially equal. This suggests that the scores given consistent and therefore reliable.

To compare the measurements of the same patient made by the two graders, the paired samples difference of means test was used. This showed a significant difference ($P < .05$). But a correlation analysis of the two complete sets of measurements showed that the Pearson rank correlation coefficient was 0.96. This suggests that while one grader consistently assigned higher values to a given measurement than the other, the two sets of data were completely consistent with a near one-to-one correspondence. Measurements from both graders showed a similar pattern.

Table 1 Standard statistics for the ABO OGS score of both graders

Grader	Mean	SD	SE mean	Mean difference	Significance (*P*)	Correlation coefficient (*r*)	Significance (*P*)
1	27.3	7.8	0.99	−1.4	< .05	0.96	< .0001
2	28.7	8.1	1.03		< .05	0.96	< .0001

SD = standard deviation, SE = standard error.

Table 2 Standard statistics for the ABO OGS score of the two treatment modalities

Modality	Mean	n	SD	SE mean	Mean difference	SE difference	*P*
SureSmile	26.3	76	6.8	0.78	−4.4	1.50	< .005
Conventional	30.7	48	8.9	1.28	−4.4	1.50	< .005

n = number of measurements, SD = standard deviation, SE = standard error.

Data analysis

ABO OGS scores: SureSmile vs conventional treatment. The independent samples difference of means test was applied to determine whether the outcomes for both clinical approaches were statistically different. It showed a significant difference ($P < .005$). The mean for SureSmile (26.3) was, on average, 4.4 points lower than that for conventional treatment (30.7) (Table 2).

Component ABO OGS scores: SureSmile vs conventional treatment. All 14 components of the overall ABO OGS score measured by the two graders were evaluated using a paired comparison *t* test. All pairs were strongly correlated (significant at the 0.95 level with Pearson rank correlation coefficients ranging from 0.76 to 0.92). This again suggests that the scores of both graders were consistent. In the interest of completeness, it should be reported that the mean score for occlusal relationship *r* of one grader was noticeably higher than that of the other. This is not surprising as this evaluation is somewhat subjective.

Next, the scores for the 14 individual components were evaluated for differences between the two clinical approaches. This data is summarized in Table 3 and Fig 1. The ABO OGS mean scores for the patients treated with SureSmile were lower for 11 components, equal for two, and higher for one. The independent sample *t* tests showed that for five of the 14 components, the SureSmile treatment resulted in a significantly lower score (95% confidence level) than the conventional treatment. For the remaining nine components, there was no significant difference between the two modes of treatment.

Treatment time. The check for treatment time (notated in months) revealed that the data was distributed approximately evenly, with only a slight skewness and no evidence of a kurtosis.

The independent samples difference of means test suggested that SureSmile significantly reduced treatment time (14.7 months vs 20.0 months, Table 4).

Level of difficulty. The level of treatment difficulty was measured by the DI. The pairwise correlation analysis of the ABO OGS between the approaches indicated no meaningful correlation between the DI and ABO OGS for patients treated with SureSmile ($r = 0.05$) or conventionally ($r = 0.04$) (Table 5). This suggests that there was no relationship between the level of difficulty and the treatment result.

Figure 1 depicts the mean scores for the components of the ABO OGS for the two graders individually. As noted above, the two Graders made statistically equivalent measurements.

Figure 2a reflects the mean score of the ABO OGS for both graders, whereas Fig 2b compares the ABO OGS score and the mean treatment time for the patients treated with SureSmile to the patients treated conventionally.

Table 3 Standard statistics for the individual components of the ABO OGS score of the two treatment modalities

Component	SureSmile		Conventional		Mean difference	Significance (*t* test, *P*)
	Mean	SE	Mean	SE		
Alignment and rotations (max)	1.8	0.09	2.7	0.14	0.9	< .05
Alignment and rotations (man)	2.0	0.11	2.3	0.14	0.3	
Marginal ridges (max)	2.0	0.11	2.5	0.17	0.5	< .05
Marginal ridges (man)	2.4	0.12	2.4	0.16	0.0	
Buccolingual inclination (max)	1.2	0.13	1.9	0.18	0.7	< .05
Buccolingual inclination (man)	2.3	0.17	1.9	0.17	−0.4	
Overjet R	2.0	0.15	2.7	0.15	0.7	< .05
Overjet L	2.2	0.14	2.5	0.17	0.3	
Occlusal contacts	3.3	0.18	3.7	0.16	0.4	
Occlusal contacts lingual	3.4	0.18	3.6	0.18	0.2	
Occlusal relationships R	1.8	0.15	2.2	0.18	0.4	
Occlusal relationships L	1.3	0.13	1.3	0.13	0.0	
Interproximal contacts R	0.2	0.05	0.4	0.07	0.2	
Interproximal contacts L	0.2	0.05	0.5	0.09	0.3	< .05

SE = standard error, max = maxillary, man = mandibular.

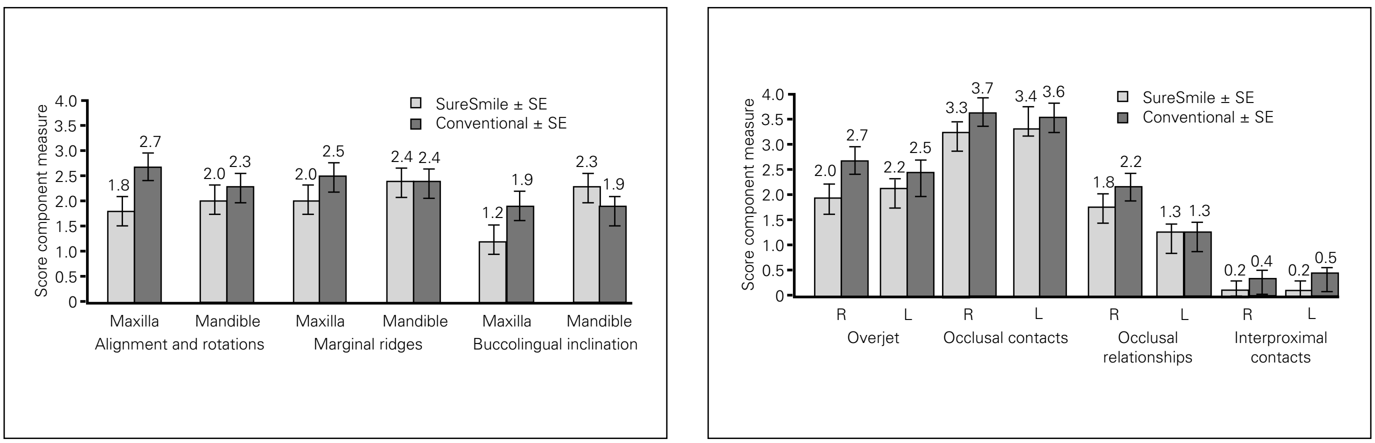

Fig 1 Results for the individual components of the ABO OGS score for both treatment modalities and both graders individually.

DISCUSSION

This study examined the efficiency and effectiveness of the SureSmile system compared to that of conventional fixed appliance straight wire therapy. Two measures were used to evaluate effectiveness: treatment time and ABO OGS score.

The average treatment time for conventionally treated patients in this study was 20.0 months with a standard deviation of 6.40 months. In contrast, in SureSmile patients, it was significantly shorter with an average of 14.7 months. This represents a 36% decrease. The treatment duration for the conventionally treated patients in this study most closely corresponds with the results reported by Skidmore et al(23.5 months),[3] Fink and Smith (23.1 months),[2] and Alger (22.0 months).[4]

Having identified this difference in treatment length, it was important to find out whether it was due to a different severity of the initial malocclusion. However, the DI scores for both patient groups were similar (m = 9.2 ± 6.6 for SureSmile, m = 11.0 ± 6.7 for conventional therapy). Further, the correlation coefficients between ABO OGS and DI were low, suggesting that severity was not a factor impacting these results.

Fig 2 ABO OGS mean scores for **(a)** both graders individually and **(b)** mean score and treatment times (in months) for SureSmile and conventional therapy.

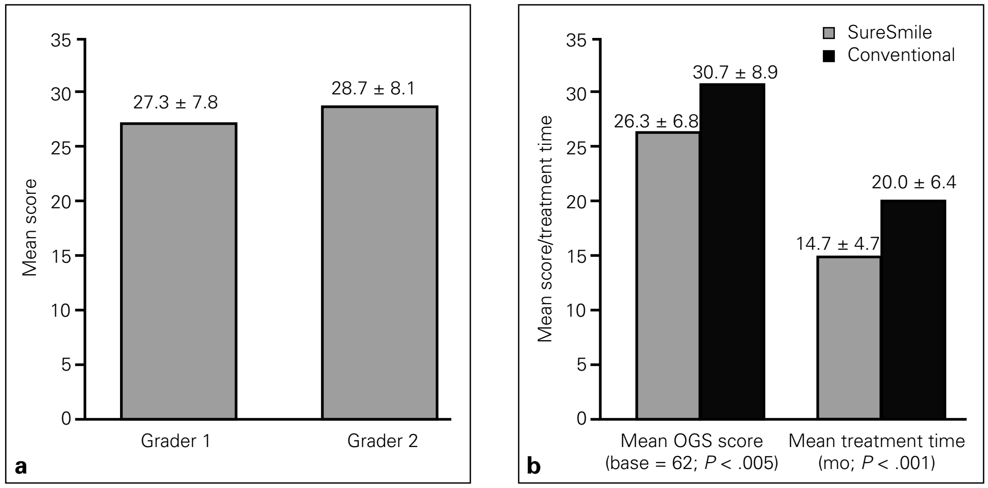

Table 4 Standard statistics for the treatment time of the two modalities

Modality	Mean	n	SD	SE	Mean difference	SE difference	*P*
SureSmile	14.7	38	4.71	0.76	−5.3	1.51	< .001
Conventional	20.0	24	6.40	1.21	−5.3	1.51	< .001

n = number of patients, SD = standard deviation, SE = standard error.

Table 5 Standard statistics for the discrepancy index (DI) of the two modalities

Modality	Mean	n	SD
SureSmile DI	9.2	76	6.58
Conventional DI	11.0	48	6.74

n= number of patients, SD = standard deviation.

Notably, the confidence level for total treatment time with SureSmile is narrower (4.71 SD) than that of conventional treatment (6.40 SD), suggesting that less variation in treatment time is to be expected when treating with SureSmile. This may translate to a better estimation of treatment time.

Part of the standard care process with conventional appliances is that toward the end of therapy, a quality result is generally accomplished through repositioning brackets, altering bracket prescriptions, and/or archwire bending. In contrast, SureSmile prescriptive archwires are derived from an optimal setup. Thus, SureSmile customized archwires overcome the vagrancies of traditional straight-wire appliances and allow for an earlier control. This may be a strong factor for reduced treatment length.

Additionally, SureSmile archwires are bent with high reliability and precision using robotic technology. Unpublished data suggests that the torsional and linear bends are accurate within ± 1 degree and ± 0.2 mm, respectively. On the other side, the bracket slots of straight-wire appliances have a very large tolerance, potentially leading to imprecise tooth movements, which are generally corrected by reactive measures resulting in prolonged care.[24,25]

In addition to a shorter care cycle, SureSmile patients demonstrated an OGS score 14.3% better compared to conventional therapy. This finding is important because the prevalent thinking is that better outcomes are related to longer treatment times.[26]

CONCLUSIONS

The treatment time for the SureSmile system compared to conventional orthodontics was significantly shorter by about 25.0%.

The ABO OGS score for the SureSmile patients was, on average, 14.3% better than for those patients treated with conventional appliances.

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