*Original Article*

# Clinical outcomes for patients finished with the SureSmile™ method compared with conventional fixed orthodontic therapy

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## ABSTRACT

**Objective:** Utilize American Board of Orthodontics (ABO) cast/radiographic evaluation (CRE) to compare a series of 63 consecutive patients, finished with manual wire bending (conventional) treatment, vs a subsequent series of 69 consecutive patients, finished by the same orthodontist using the SureSmile™ (SS) method.

**Materials and Methods:** Records of 132 nonextraction patients were scored by a calibrated examiner blinded to treatment mode. Age and discrepancy index (DI) between groups were compared by *t*-tests. A chi-square test was used to compare for differences in sex and whether the patient was treated using braces only (no orthopedic correction). Analysis of covariance tested for differences in CRE outcomes and treatment times, with sex and DI included as covariates. A logarithmic transformation of CRE outcomes and treatment times was used because their distributions were skewed. Significance was defined as $P < .05$.

**Results:** Compared with conventional finishing, SS patients had significantly lower DI scores, less treatment time (∼7 months), and better CRE scores for first-order alignment-rotation and interproximal space closure; however, second-order root angulation (RA) was inferior.

**Conclusion:** SS patients were treated in less time to better CRE scores for first-order rotation (AR) and interproximal space closure (IC) but on the average, malocclusions were less complex and second order root alignment was inferior, compared with patients finished with manual wire bending. (*Angle Orthod.* 2011;81:383–388.)

**KEY WORDS:** SureSmile™; Clinical outcomes; Finishing; Treatment time

## INTRODUCTION

New orthodontics products and treatment systems often claim to produce better, faster, and more efficient results, but rarely is any independent scientific validation performed. SureSmile™ (OraMetrix, Richardson, Tex) is a computer-aided treatment concept introduced in 1998, but not released commercially until around 2005. In the present context, the SureSmile (SS) method is used to facilitate orthodontic finishing. The SS process digitally captures three-dimensional (3D) images of the teeth and brackets. Computer software develops a 3D therapeutic model of the patient's dentition, and a virtual treatment plan (VTP) is formulated, which then guides a computer-aided robot to bend and reprogram the form of nickel-titanium (NiTi) archwires, to move the teeth into desired positions.[1] Sachdeva et al.[1–4] describe the SS process and philosophy of treatment to create a "patient-centered practice" that delivers high-quality care while minimizing discomfort, compliance demands, chair time, and treatment duration. Furthermore, SS is touted to reduce bending wire errors, thereby shortening treatment time without sacrificing the quality of the result.[2]

In 1998, the American Board of Orthodontics (ABO) initiated a series of objective assessments for facilitating the board certification process.[5] The Discrepancy

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**Table 1.** Ranges and Mean ± Standard Error (SE) Distributions for CRE Scores[a]

| | Conventional (n = 63) | | | SureSmile (n = 69) | | |
|---|---|---|---|---|---|---|
| | Min | Max | Mean (SE) | Min | Max | Mean (SE) |
| Age (start of treatment) | 12 | 60 | 17.8 (0.8) | 13 | 60 | 18.1 (0.9) |
| DI (Discrepancy Index) | 3 | 40 | 15.8 (0.9) | 1 | 33 | 13.2 (0.9) |
| AR (alignment and rotations) | 0 | 10 | 4.0 (0.3) | 0 | 7 | 2.7 (0.2) |
| MR (marginal ridges) | 0 | 12 | 5.2 (0.3) | 0 | 16 | 5.3 (0.4) |
| BL (buccal-lingual) | 0 | 6 | 2.7 (0.2) | 0 | 8 | 2.7 (0.2) |
| OJ (overjet) | 0 | 9 | 2.8 (0.2) | 0 | 10 | 2.7 (0.3) |
| OC (occlusal contacts) | 0 | 12 | 2.2 (0.3) | 0 | 10 | 2.0 (0.3) |
| OR (occlusal relationship) | 0 | 10 | 2.3 (0.3) | 0 | 7 | 1.6 (0.2) |
| IC (interproximal contacts) | 0 | 5 | 0.5 (0.1) | 0 | 2 | 0.2 (0.1) |
| RA (root angulation) | 0 | 7 | 0.9 (0.2) | 0 | 5 | 1.3 (0.2) |
| Total CRE score | 9 | 38 | 20.8 (0.8) | 6 | 38 | 18.5 (1.0) |
| Tx time: total | 14 | 71 | 32.0 (1.6) | 7 | 78 | 22.7 (1.5) |
| Tx time: in braces alone | 12 | 38 | 23.6 (0.7) | 7 | 35 | 16.7 (0.8) |
| Tx time: in braces-only patients | 14 | 31 | 23.0 (1.0) | 7 | 31 | 15.8 (1.0) |

[a] CRE indicates cast/radiographic evaluation; max, maximum; min, minimum; and Tx, treatment.

Index (DI) and cast/radiographic evaluation (CRE) scores have proved to be effective research tools for assessing clinical outcomes.[6–13] The CRE assesses treatment outcomes by measuring eight different parameters of dental morphology: (1) alignment and rotations (AR), (2) marginal ridge adaptation (MR), (3) buccal-lingual (BL) inclination of the posterior segments, (4) overjet (OJ), (5) occlusal contacts (OC) of the posterior segments, (6) occlusal relationship (OR) of the posterior segments (sagittal plane), (7) interproximal contacts (IC), and (8) root angulation (RA), as measured on a panoramic radiograph. Points are added for each deviation from ideal in all eight categories.

Several methods have been developed to measure malocclusion severity, or need, as assessed by the world community.[14–18] The CRE has been used to study orthodontics outcomes in several clinical samples such as graduate orthodontics programs[6–11] and patients treated with clear aligners,[12] and to assess the impact of indirect bonding on the final result.[13] These studies demonstrated that the DI and CRE are effective research tools for assessing the complexity of a malocclusion and the outcome of orthodontics treatment under a variety of clinical conditions.

Initially, a 48% decrease in treatment time was reported for a limited number of patients treated with the SS protocol,[3] but the data were difficult to interpret because of the limited number of patients and a remarkably low average CRE score of 7.5. More recently, Moles[4] reported an average treatment time of 13.1 months for 500 patients treated with SS since the technology was incorporated into routine practice. Neither Moles[4] nor Sachdeva et al.[3] statistically analyzed their data, and sampling methods are suspect because no mention was made of how patients were assigned to each treatment category.

The purpose of the present study is to investigate treatment duration relative to outcomes (CRE) and malocclusion complexity (DI) for SS and conventional treatment, rendered under similar conditions by the same orthodontist.

## MATERIALS AND METHODS

The assessor did not treat patients and was blinded as to the treatment method. This was a convenience sample of 146 consecutively finished, cooperative patients, treated without extractions. The same ABO-certified orthodontist, who had 2 years of SS experience, finished each patient with manual wire bending (conventional) or the SS technique. The same experienced clinical examiner trained and calibrated the assessor in the use of CRE and DI methods, using standardized patient records as previously described.[6–10] Case selection consisted of the following: (1) second molars erupted and in occlusion, (2) no dental agenesis, (3) no documented compliance problems, (4) all patients treated to an optimal result in the opinion of the treating orthodontist, and (5) no extractions performed. Because of incomplete records, 14 patients were disqualified, leaving 63 finished conventionally and 69 finished with SS. The groups were compared for pretreatment differences using age, sex, and beginning DI as covariates.

All radiographs were transferred electronically from the treating office directly to the assessor, and the casts were shipped by mail. The DI was determined for each patient as specified by the ABO.[17] The CRE score for each patient was reported, along with scores on the eight components (Table 1). The groups were statistically compared, relative to differences in DI and total CRE score, as well as for each of its eight components. Patient histories and treatment notes were sent for the assessor's review after scoring was completed, and casts were returned to the treating orthodontist's office. Therefore, the assessor was blinded to all aspects of treatment during the scoring process. Total treatment time was calculated for each patient. Any initial orthopedic treatment or rest phase (retention or guidance of eruption) was not considered part of the active treatment time. Patients in both groups were divided into braces only (no orthopedic treatment) and braces plus orthopedic therapy (two-phase treatment).

Two-sample *t*-tests were used to compare conventional and SS groups for differences in age and DI. A chi-square test was used to compare the two groups for differences in sex and whether the patient was treated using braces only (no orthopedic intervention). Analysis of covariance was used to compare the groups for differences in CRE outcomes and treatment times, with sex and DI included as covariates, because they are known factors that can influence CRE outcomes and treatment times. A logarithmic transformation of CRE outcomes and treatment times was used because their distributions were skewed.

## RESULTS

Table 1 compares conventional vs SS patients relative to age, DI, scores on components of the CRE, total CRE score, and treatment time (with or without orthopedic therapy). The conventional group was composed of 63 patients, and the SS group included 69. Although the conventional group was 51% male, compared with an SS group that was only 38% male, this trend was not statistically significant ($P = .13$). No significant difference was noted between groups in terms of patient age ($P = .80$), but the SS group had significantly lower DI scores ($P = .0423$). Forty (58%) in the SS group were treated only with braces, with no early (phase 1) treatment or orthopedic appliances, but only 24 (38%) in the conventional group were treated using only fixed appliances ($P = .0225$).

Compared with those given conventional treatment, SS patients had lower AR scores ($P = .0004$), reduced IC scores ($P = .0152$), less total treatment time ($P = .0001$), reduced treatment time in braces ($P = .0001$), and reduced treatment time in braces-only patients ($P = .0001$). A strong trend was observed toward SS producing a lower total CRE score ($P = .0541$) and a higher RA score ($P = .0692$), compared with conventional treatment. The two groups did not have significantly different MR ($P = .86$), BL ($P = .56$), OJ ($P = .49$), OC ($P = .71$), or OR scores ($P = .10$) (Table 1).

## DISCUSSION

Caution must be used when interpreting the results of the current study because (1) SS patients had significantly ($P = .0423$) fewer complex malocclusions (Figure 1), (2) SS patients were usually treated with only fixed appliance alignment (no orthopedics), as documented in Table 1, and (3) root angulation was scored on panoramic radiographs. Although the evaluator was blinded to treatment mode, the sample was not randomized. This study provides initial insight into the problem, but a definitive comparison requires a randomized clinical trial using 3D imaging for assessment.

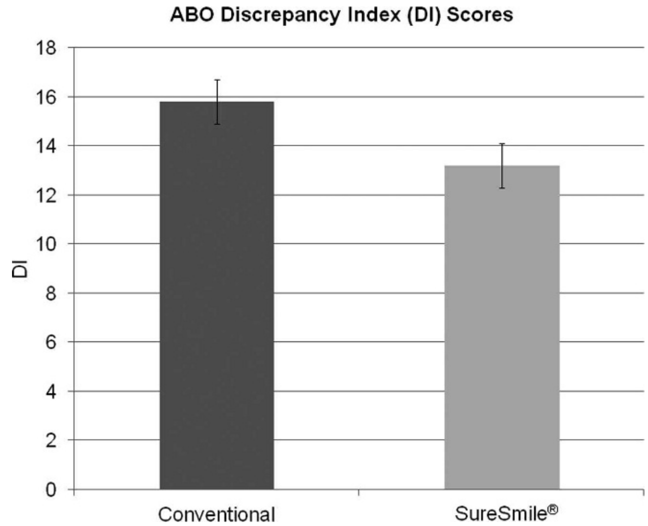


**Figure 1.** DI scores for patients finished with SureSmile and conventional orthodontics methods (mean ± SE).

The mean DI of 13.2 for the SS group was significantly less than the 15.8 mean value reported for the conventional group ($P = .0423$). Sachdeva[3] reported little correlation between the outcome assessment and the beginning DI; however, other authors[6,8,10] with much larger patient samples found a positive correlation between beginning DI, CRE score, and length of treatment. By using age, sex, and DI as covariates in the analysis, the analysis accounts for group differences as much as can be done in a nonrandomized sample.

A trend ($P = .0541$) toward lower total CRE scores was seen in the SS group, but the difference was not statistically significant (Figure 2). The conventional group showed a trend toward a higher percentage of male patients (51% vs 39%). Several authors[6–9] have shown a positive correlation between males and increased CRE scores. Thus, the present conventional treatment group may be prone to higher CRE scores because it consists of more complex malocclusions and a larger fraction of males.

Analysis of CRE components (Figure 3) shows that SS produced a more favorable outcome in the AR and IC components. The lower AR scores may be attributed to increased accuracy of the automated

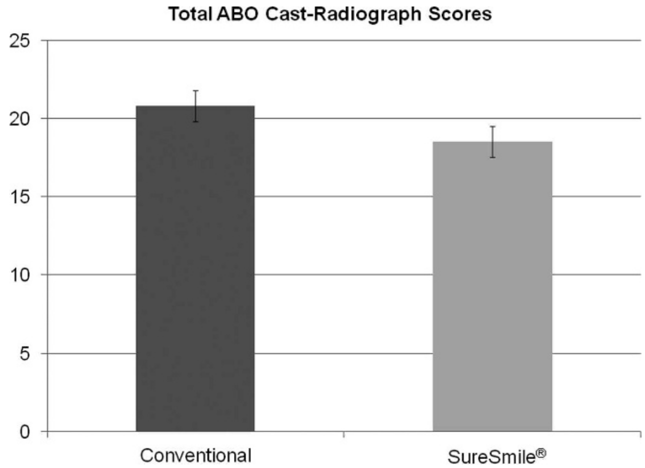


**Figure 2.** Final alignment scores via ABO cast/radiograph evaluation (CRE) for patients finished with SureSmile and conventional orthodontics methods (mean ± SE).

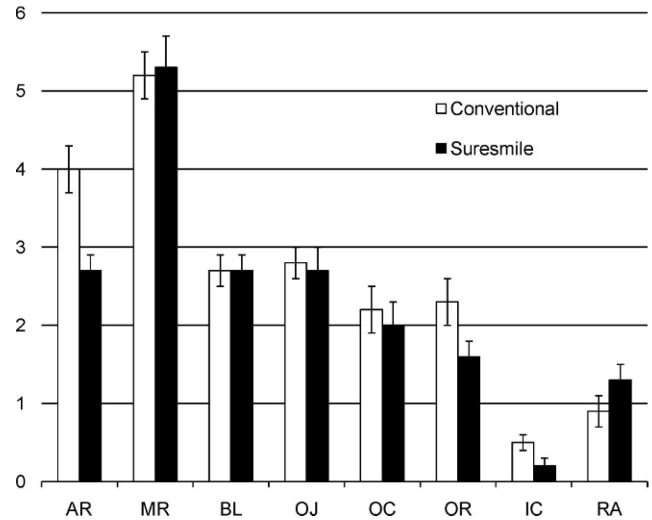


**Figure 3.** Total treatment (Tx) time for each group was subdivided into Tx time in braces (fixed appliances on the teeth) and Tx time in braces only (no orthopedic Tx) (mean ± SE).

system in achieving appropriate bends in NiTi wire to accomplish desired tooth movement; this result is consistent with the SS goal to limit treatment errors.[1–3] An inaccurate bend in an archwire may introduce an iatrogenic problem that requires additional treatment time. If the SS robotic device routinely achieves bends in archwires that preserve superelastic properties,[19] then an increased range of activation may contribute to more favorable alignment of the crowns of the teeth compared with manually bent archwires.

The trend in IC was surprising because no patients were treated with extraction therapy. Although the practitioner may have placed inappropriate finishing bends, other biomechanical explanations could be offered for the increase in interproximal spaces that is likely to occur. Interproximal spaces in the finished occlusion may be due to side effects of biomechanics, intermaxillary tooth size discrepancies, and/or residual band spaces. First, application of second-order moments to correct axial inclinations commonly results in space opening, unless the entire arch is secured with cinch-back bends, figure-eight ligatures, or elastic chains. Thus, manual wire bending may result in a greater number of interproximal spaces as a side effect of efficient root paralleling. SS treatment may be less prone to this problem because teeth tend to be tipped into an optimal alignment of the crowns. Second, more complex malocclusions are more likely to express abnormal dental anatomy and intermaxillary tooth size discrepancies, both of which may elevate the DI score.

An interesting result was the trend toward a lower (better) score in conventional cases with respect to root angulation (RA). SS effectively tipped the crowns of the teeth to the desired position, but the roots were not as well aligned. This problem may reflect an inefficiency of SS archwires in second-order tooth movement, more relaxed finishing standards for SS compared with conventional treatment, and/or a radiographic error that is determining axial inclination. Studies have shown that root position can vary by as much as 25 degrees, depending on the panoramic beam angle of radiation.[20,21] The tendency for incomplete axial inclination correction may lie in the SS emphasis on shorter treatment time. The relatively light forces expected from NiTi wires via the SS system may tend to tip the crown of the tooth into the desired position, but an adequate moment to efficiently align the roots may be lacking. Because of a desire to decrease treatment time, the clinician may have allowed insufficient time for root movement once the crowns were aligned.

In the other five areas of the CRE grading system—MR, BL, OJ, OR, and OC—no differences between the two groups were reported. In theory, the SS system should score lower (better) in all areas if the bends are more accurate than those of conventional treatment. These data suggest that the SS approach has little effect on most of the components of the CRE score.

Figure 4 shows differences in treatment times between the two groups. In all three categories, treatment times were lower for the SS patients. This difference was statistically significant ($P = .0001$) for the three groups. In all cases, including both one- and two-phase treatment, overall treatment times were decreased with SS. Because the treatment time in the orthopedic portion of treatment (~6 months) was the same for the two groups, the time savings occurred in the fixed appliance portion of therapy. On average, SS technology decreased treatment time by about 7 months compared with conventional therapy. Be-

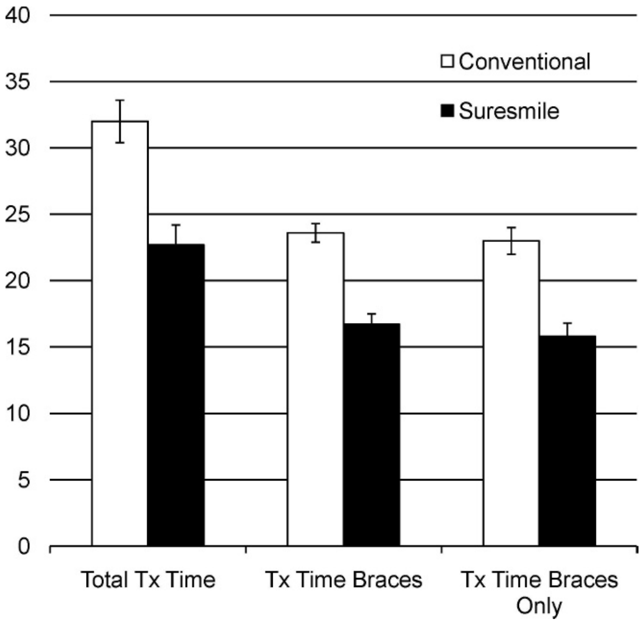


**Figure 4.** Final alignment scores, determined by ABO cast/radiograph evaluation (CRE), were subdivided into each of the eight components as defined in Table 1 (mean ± SE).

cause this was not a randomized clinical trial, many uncontrolled variables may be manifest in the results. Because the selection criteria for this study applied to nonextraction cases, it would be interesting to evaluate extraction cases, especially considering the apparent increase in problems with root movement and paralleling associated with SS.

Recently, Sax et al.[22] compared outcomes of 38 SS patients vs 24 conventionally treated patients drawn from the private practices of three orthodontists. They reported that SS resulted in better CRE outcomes with less treatment time. These results must be interpreted with caution because neither the patient selection methods nor the distribution of cases among the three orthodontists was clear. In comparison, SS and conventionally treated patients assessed in the present study were given consecutive finishes by the same orthodontist.

Determining the CRE scores of patients about 7 months before the end of active treatment would provide a more effective assessment of the finishing potential of SS compared with conventional mechanics. Pinskaya et al.[6] showed a diminishing return on treatment quality as treatment duration increased and patient cooperation declined ("burnout"). However, it is also possible that during finishing, the result is better in one area but declines in other areas, as the clinician pursues an optimal result. A clinician may be more inclined to remove appliances when first- and second-order alignment is improved with SS treatment. When crowns of teeth are well aligned, it may be more difficult to detect axial inclination problems.

This study could be improved by performing a prospective, randomized, blinded study to compare treatment using SS technology vs conventional treatment. Also, it would be germane to measure the CRE at the start of finishing, to see whether the terminal 6 months or so of treatment has a significant effect on overall CRE score. Such a well-structured study would best be accomplished in a university setting.

## CONCLUSIONS

- SS computer-aided treatment produced significantly lower CRE scores in the first-order alignment and rotation and interproximal space closure categories.
- Trends favored lower total CRE score for SS patients, but second-order root alignment (RA) scores were inferior for SS compared with conventional treatment.
- SS cases had significantly less treatment time (~7 months) for patients treated in two phases and those treated with braces alone. For patients receiving two-phase treatment (orthopedic treatment), the decreased treatment time was attributable only to the time in fixed appliances.
- Decreased treatment time with SS is tempered by less complex malocclusions (lower DI, less orthopedics) in the SS group and inferior second-order root alignment.
- A randomized clinical trial is needed to determine whether the SS approach has an effect on treatment efficiency (results vs treatment time).

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