Treatment time: SureSmile vs conventional

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Aim: *To understand the efficiency of SureSmile treatment vs conventional treatment.* ***Methods:*** *First, 12,335 completed patient histories representing different treatment philosophies and geographically diverse practices were collected. Included were 9,390 SureSmile patients and 2,945 conventional patients. Variables in these patient records included:* (1) *treatment time, months from bonding to debonding;* (2) *malocclusion class, Angle Class I, II, or III;* (3) *patient age, adolescents (< 18 years) or adults (≥ 18 years); and* (4) *patient visits, total number of treatment visits. Nonparametric regression tests were used to analyze the data.* ***Results:*** *The median treatment time for the SureSmile patient pool (15 months) was 8 months shorter than that of the conventional patient pool (23 months). The median care cycle length of Class II SureSmile patients (13 months) was 2 months shorter than that of Class I SureSmile patients (15 months) and 3 months shorter than that of Class III SureSmile patients (16 months). SureSmile patients (14 visits) had four fewer median treatment visits than conventional patients (18 visits). All results were significant at* P = .001. *No significant differences were noted between the median care cycle lengths of adolescents and adults.* ***Conclusion:*** *This study found that SureSmile treatment facilitates more timely care than conventional treatment. Further prospective studies are required to elucidate the effectiveness of SureSmile treatment.* ORTHODONTICS (CHIC) 2012;13:72–85.

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Patients frequently consider length of treatment as a factor in their decision to pursue orthodontic care.[1–4] Hickory[5] evaluated responses from 1,520 orthodontic patients to better understand what they were willing to pay for a reduced-length care cycle. His study determined that a quarter of respondents were willing to pay a 40% premium for a 30% reduction in time. The majority of respondents did not object to paying 10% more for reduced treatment time. Therefore, it is clear that many patients are willing to cover greater costs for shorter treatment times. Numerous studies have also demonstrated a positive correlation between shorter orthodontic treatment time and patient satisfaction.[6–9]

Healthcare policymakers have recognized the importance of shorter treatment times. The Institute of Medicine advocates efficiency, effectiveness, and timeliness of care as three of the six dimensions of quality care.[10] The British Orthodontic Society recommends that patients be adequately informed regarding the length of care.[11] Extended length of care negatively affects patient compliance and may result in poor quality of care.[12–14] Furthermore, an extended care cycle adversely affects clinical operations, productivity, and revenue generation.[15,16] Patients, parents, and practices all benefit from a shorter, more predictable care cycle. Therefore, it is imperative for clinicians to understand the factors that impact orthodontic treatment duration in hopes of maximizing patient convenience and practice productivity.

Studies note that treatment time generally ranges from 18.3 to 31.3 months.[2,3,17,18] Sameshima[19] reported a mean treatment time of 28 months in North America. The wide range in duration of treatment is probably due to the varying interactions of factors such as patient sex, age at onset of care, patient compliance, severity of malocclusion, nature of treatment, type of appliances, and the experience of the care provider.[6,19–21]

In the past decade or so, orthodontics has witnessed the development of new technologies in the fixed appliance arena, namely Insignia (Ormco), orthoCAD (Cadent), iBraces (3M Unitek), and SureSmile (OraMetrix). These technologies enable clinicians to provide computer-driven customized care solutions at varying levels. By minimizing the reactive care process, SureSmile has the transformative potential of affecting the duration of orthodontic care in clinical practice.[22–26]

SureSmile was designed to provide a completely integrated, clinical solution to the extended care cycle. Three-dimensional (3D) imaging, clinical decision support, treatment surveillance, and customized therapeutics enable orthodontists to minimize iterative care processes and potentially reduce the duration of care without compromising quality.[23–33] Saxe et al[34] recently studied the efficiency and effectiveness of SureSmile vs conventional treatment. The authors collected 62 pre- and posttreatment plaster casts of consecutively treated SureSmile patients and conventionally treated patients from the practices of three diplomates of the American Board of Orthodontics (ABO). The mean ABO objective grading system (OGS) score was 26.3 for SureSmile and 30.7 for conventional treatment. This difference of 4.4 points was significant at $P = .001$. The mean treatment time with SureSmile was 14.7 months vs 20 months for conventional treatment ($P = .001$). SureSmile demonstrated a 25% reduction treatment duration and an improvement of 14.3% in ABO OGS scores.[34] Similarly, Alford et al compared the treatment times of 69 SureSmile and 63 conventionally treated patients. The mean treatment time with SureSmile was 15.8 months vs 23 months for conventional treatment. SureSmile demonstrated a 31% reduction treatment duration and an improvement of 11% in ABO cast/radiographic evaluation (CRE) scores.[35]

The purpose of this study is to understand the efficiency of SureSmile using a larger sample size while considering different variables than previous studies. Although Saxe et al[34] and Alford et al[35] provided the initial steps in identifying the clinical benefits of SureSmile, the robust sample size (12,335 patients) and diversified practitioner base (142 practices) characteristic of this study allows for a clearer understanding of the clinical impact of SureSmile on the duration of the care cycle.

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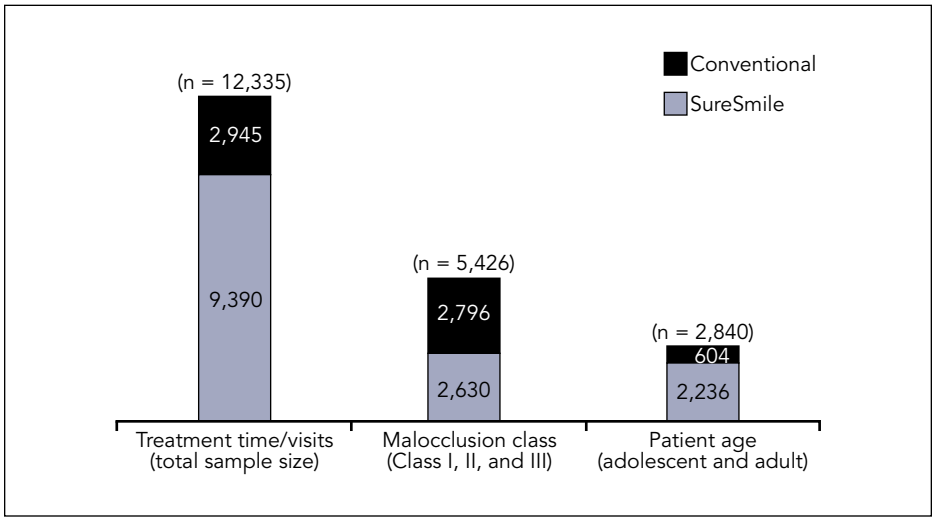

Fig 1 Sample size and variables studied.

METHODS

In 2003, OraMetrix developed an ongoing system to collect completed treatment records of both SureSmile and conventional patients from volunteer SureSmile practices. The purpose of the system is to elucidate clinicians' performance characteristics and provide feedback on better clinical practices. By 2008, this program, Comparative Effectiveness Research Program (CERP), received more than 12,000 completed orthodontic patient histories from a diverse group of geographical practices, patient types, treatment philosophies, and clinician experiences. This is the first extensive study dedicated to investigating SureSmile's impact on the duration of treatment time as well as factors that influence treatment time.

Patient samples

This study used the CERP database from 2003 through 2008, which consisted of data submitted by 142 SureSmile practices throughout the United States. At the time of analysis, a total of 12,335 patient records had been submitted, containing a mix of two treatment types: SureSmile (9,390 patients) and conventional (2,945 patients). Variables in these patient records included: *(1)* treatment time, months from bonding to debonding; *(2)* malocclusion class, Angle Class I, II, or III; *(3)* patient age, adolescents (< 18 years) or adults (≥ 18 years); and *(4)* patient visits, total number of treatment visits (Fig 1).

Some records were incomplete as they lacked information on the distribution of Angle classification of malocclusion and patient age. Hence, these incomplete records could not be used for the analysis of these variables, resulting in the smaller samples as shown in Fig 1.

This study did not utilize any protected patient medical or dental information by the practices. Only selective treatment attributes were used for the analysis. Therefore, institutional review board approval was not obtained.

Data analysis

The objective of this analysis was to statistically identify and quantify the key determinants of the efficiency of SureSmile protocol vs conventional orthodontic treatment. The parameter for statistical significance was a *P* value less than .001.

Table 1 Mean and median values for treatment months

Treatment	n	Median	Mean	SD	Mean difference	Significance
SureSmile	9,390	15	16	6.75	8	< .001
Conventional	2,945	23	24	8.24		

SD, standard deviation.

Table 2 Mean and median values for treatment months by patient class

Class	Treatment	n	Median	Mean	SD	Mean difference	Significance
I	SureSmile	1,478	15	16	6.92	8	< .001
	Conventional	1,202	22	24	9.23		
II	SureSmile	892	13	14	5.68	9	< .001
	Conventional	773	22	23	6.86		
III	SureSmile	260	16	17	7.19	8	< .001
	Conventional	821	24	25	8.33		

SD, standard deviation.

The CERP data had a significant degree of skewness and kurtosis and were not normally distributed, rendering conventional regression analysis inappropriate. (Skewness and kurtosis were calculated as the third and fourth moments of a distribution, respectively. Measures of skewness and kurtosis equal to or greater than twice their respective standard errors were deemed to show a significant departure from normality.) Therefore, nonparametric regression was used to analyze the data via SPSS (IBM). This methodology requires that all records contain a complete set of variables; however, as previously noted, some records were incomplete and could not be used for statistical analysis. All 12,335 records were used for treatment time analysis, although only subsets of the record pool containing attributes other than treatment time were used for malocclusion and age analysis.

RESULTS

Treatment months

SureSmile patients experienced shorter treatment times than conventinal patients. SureSmile patients experienced 15 months of median treatment time, while conventionally treated patients experienced 23 months of median treatment time (Table 1).

Malocclusion class

The shorter treatment time associated with SureSmile was evident for all classes of patients. SureSmile Class I, II, and III patients experienced 15, 13, and 16 months of median treatment time, respectively, while conventionally treated Class I, II, and III experienced 22, 22, and 24 months of median treatment time, respectively (Table 2).

Patient age

Where patient age was available, patients were grouped as either adolescents (younger than 18 years) or adults (ages 18 and older). Median treatment times for both SureSmile adolescents (16 months) and adults (15 months) were significantly less than those of conventionally treated adolescents and adults (both

Table 3 Mean and median values for treatment months by patient age

Treatment	Group	n	Median	Mean	SD	Mean difference	Significance
Adolescents	SureSmile	1,382	16	16	7.18	8	< .001
	Conventional	479	24	25	8.14		
Adults	SureSmile	854	15	17	7.14	9	< .001
	Conventional	125	24	25	9.07		

SD, standard deviation.

Table 4 Mean and median values for treatment visits

Treatment	n	Median	Mean	SD	Mean difference	Significance
SureSmile	9,390	14	15	6.16	4	< .001
Conventional	2,945	18	19	7.31		

SD, standard deviation.

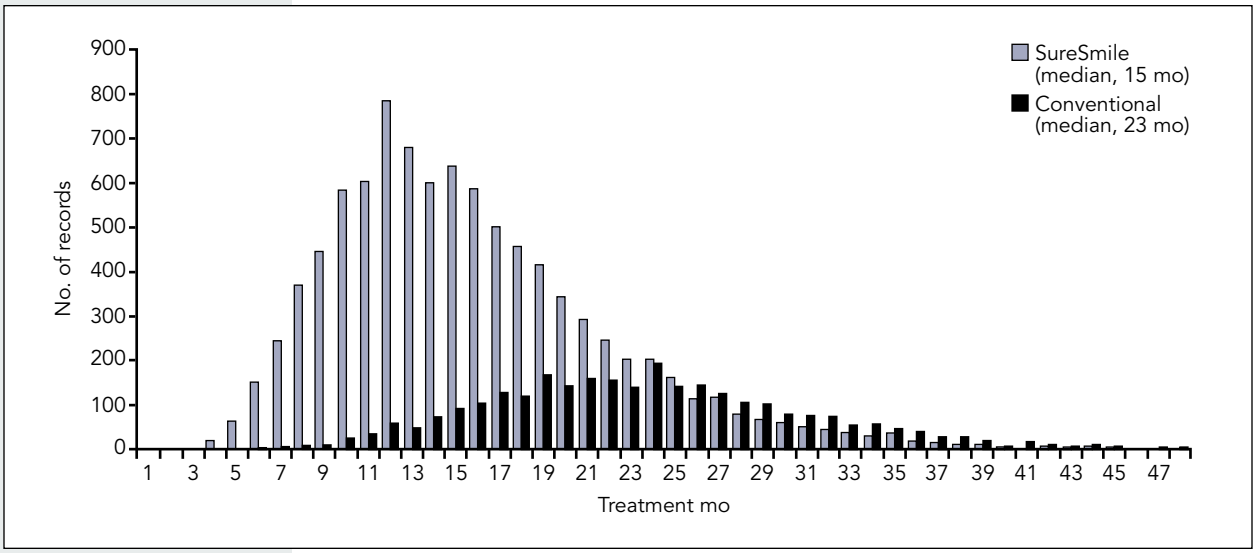

Fig 2 Frequency distribution of median treatment times for both treatment groups.

24 months). Patient age appears to exert only a modest influence on SureSmile treatment efficiency, for the median length of treatment time for adults was just 1 month less than that of adolescents (Table 3).

Treatment visits

With a median treatment time of 8 months less than that of conventionally treated patients, SureSmile patients also experienced four fewer median treatment visits than conventional patients. SureSmile patients experienced a median of 14 visits to their orthodontist over the course of treatment, while conventional patients experienced a median of 18 visits (Table 4).

Frequency distribution of the data

Plots of CERP data distribution also demonstrate treatment time trends. Figure 2 shows the distribution of the median treatment times for both SureSmile and

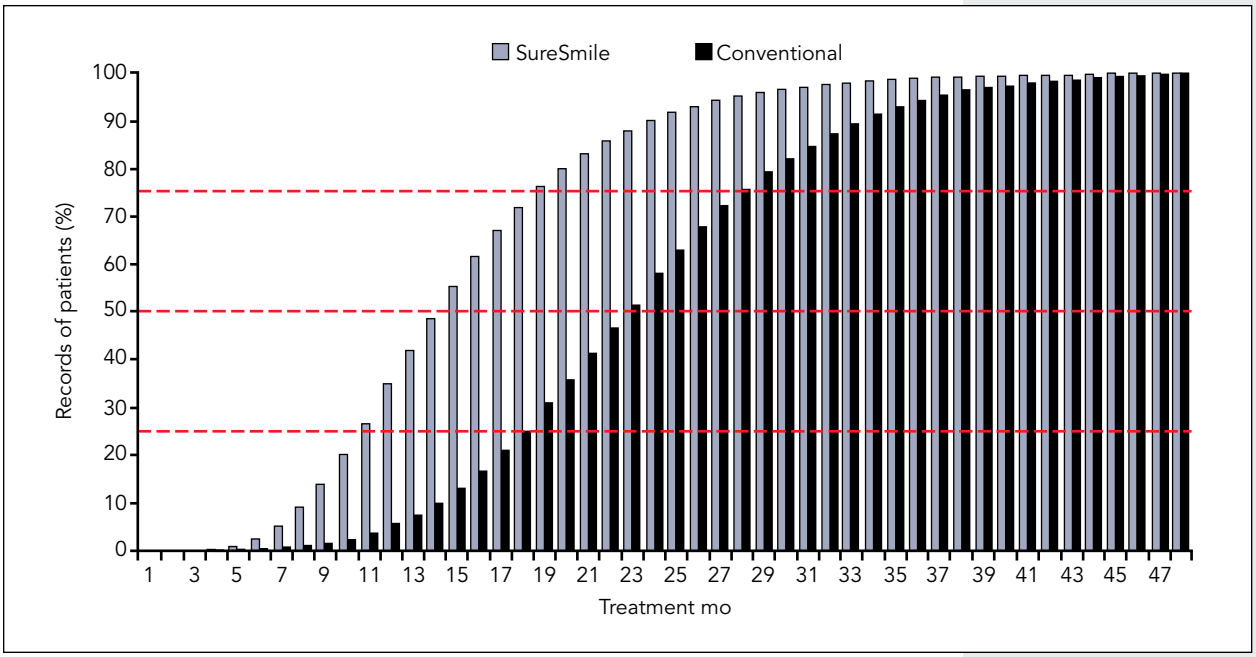

Fig 3 Percentiles of patients treated as a function of time for both treatment groups.

conventional patients. The median value for SureSmile treatment time was 8 months less than that of conventional treatment. Figure 3 shows the percentiles of patients treated as a function of time for both treatment groups. Fifty percent of SureSmile patients experienced a care cycle of 15 months or less, while 50% of conventionally treated patients experienced a care cycle of 23 months or less (Fig 3).

DISCUSSION

The purpose of this study was to understand the efficiency of SureSmile vs conventional treatment. Variables studied were treatment time, number of treatment visits, malocclusion class, and patient age.

Treatment time analysis

Various authors have studied the influence of factors, such as severity of malocclusion, treatment method, patient age, and type of appliance, on the length of treatment time. Table 5 summarizes the results of previous studies on the duration of the care cycle. As shown in Table 5, many of these studies were limited by sample sizes ranging from 5 to 605 patient records. Depending upon the variable studied, the average treatment time of conventional methods ranged from 19.1 to 57 months.

Studies on the efficiency of customized digital therapeutics are generally lacking. However, a number of investigations have been conducted on SureSmile, albeit on limited sample sizes. Saxe et al[34] studied 38 SureSmile and 24 conventional patients from three clinicians, and Alford et al[35] studied 69 SureSmile and 63 conventional patients from one clinician. Conversely, the current study was conducted on 9,390 SureSmile and 2,945 conventional patients from 142 practices.

Table 5a Studies reviewed and grouped according to their characteristics and findings: Type of malocclusion

Article	Classification of malocclusion	Total sample size	Mean treatment time (mo)
Wenger et al[36]	Class I	605	26 ± 13.4
Vig et al[37]	Class I	399	24.6 ± 11.6
Skidmore et al[2]	Class I	135	21.9 ± 4.6
Popowich et al[38]	Class I	77	20.3 ± 6.0
Campbell et al[39]	Class I	146	38.5 ± 14.3
O'Brien et al[40]	Class II Division 1	250	28.1
Wenger et al[36]	Class II	760	29.9 ± 12.2
Vig et al[37]	Class II	567	29.0 ± 11.2
Skidmore et al[2]	Class II	226	24.5 ± 4.5
Popowich et al[38]	Class II Division 1	160	24.4 ± 6.2
Janson et al[41]	Class II	97	25.8
Janson et al[42]	Class II	112	28.2
Campbell et al[39]	Class II Division 1	36	42.6 ± 14.8
Wenger et al[36]	Class III	52	28.0 ± 17.0
Skidmore et al[2]	Class III	5	23.0 ± 5.3
Cassinelli et al[43]	Easy Difficult	Easy (95) Difficult (84)	Easy (24.8 ± 17.4) Difficult (33.8 ± 12.8)

Table 5b Studies reviewed and grouped according to their characteristics and findings: Type of treatment

Article	Treatment method	Total sample size	Mean treatment time (mo)
Alger[44]	Nonextraction Extraction	37 55	19.1 23.7
Vig et al[45]	Class II Division 1 extraction Class II Division 1 nonextraction	236 202	31.3 ± 13.2 31.2 ± 14.6
O'Brien et al[40]	Class II extraction Class II nonextraction	171 79	30.6 ± 10.4 24.8 ± 9.2
Vig et al[37]	Class I and II extraction Class I and II nonextraction	411 583	29.4 ± 11.3 24.0 ± 11.2
Popowich et al[38]	Class I nonextraction Class II Division 1 nonextraction Class II Divison 1 extraction	77 81 79	20.3 ± 6.0 25.7 ± 6.8 25.0 ± 5.5
Janson et al[41]	Class II maxillary premolar extraction Class II four premolar extraction	49 48	23.5 ± 5.86 28.1 ± 7.59
Janson et al[42]	Class II nonextraction Class II maxillary premolar extraction	43 69	29.7 ± 9.7 26.7 ± 10.5
Campbell et al[39]	Class II extraction	30	44.0 ± 14.5
Luther et al[46]	Orthodontic/orthognathic surgery	69	Presurgical (27 [range, 7–47]) Postoperative (8 [range, 5–11])
Hall et al[47]	Surgical-orthodontic treatment: (extraction vs nonextraction and leveling of the curve of Spee before or after operation)	37	26.8 Presurgical (17.5)

Table 5c Studies reviewed and grouped according to their characteristics and findings: Age of patient

Article	Age group	Total sample size	Mean treatment time (mo)
Robb et al[18]	Adults Adolescents	32 (mean age, 31.3 y) 40 (mean age, 12.9 y)	30.6 ± 8.0 29.4 ± 8.8
Von Bremen and Pancherz[48]	Early mixed Late mixed Permanent	54 104 46	57 33 21
Hsieh et al[49]	Early Late	86 (mean age, 10.5 y) 322 (mean age, 13.4 y)	45.2 ± 15.4 33.3 ± 11.7
Campbell et al[39]	Adults Early treatment	45 (mean age, 32.3 y) 134 (mean age 10.8 y)	Adults (41.2 ± 12.61) Early treatment (49.0 ± 12.61)

Table 5d Studies reviewed and grouped according to their characteristics and findings: Type of appliance

Article	Type of appliance	Total sample size	Mean treatment time (mo)
Von Bremen and Pancherz[48]	Appliance: functional (with or without preceding expansion with maxillary plates), combination (functional and fixed appliances in combination), Herbst (in combination with multibracket appliances), and multibracket	Functional (32) Combination (91) Herbst (42) Multibracket (39)	Functional (38) Combination (49) Herbst (19) Multibracket (24)
Breuning et al[50]	Class II (skeletal) treatment groups: group A (headgear–activator, fixed appliances, and intraoral osteodistraction of the mandible), group B (fixed appliances and intraoral distraction), and group C (fixed appliances and bilateral sagittal split osteotomy)	Group A (10) Group B (19) Group C (13)	Group A (44.2 [range, 29–63]) Group B (28.6 [range, 16–40]) Group C (34.7 [range, 19–55])
Amditis and Smith[51]	Fixed appliances (bracket slots) 0.018-inch 0.022-inch	64	21.0 0.018-inch (20.2) 0.022-inch (21.7)
Eberting et al[52]	Bracket type: Damon self-ligating Steel ligature/elastomeric O ring	Damon (52) Conventional (48)	Damon (14.4–23.4) Conventional (22.8–32.6)
Tagawa[53]	Bracket type: Damon self-ligating Conventional self-ligating	Damon (66) Conventional (66)	Damon (20.3) Conventional (27.5)
Clark and Gebbie[54]	Bracket type: In-Ovation R Conventional	In-Ovation R (114) Conventional (241)	In-Ovation R (19.8) Conventional (23.7)
Mascarenhas and Vig[55]	Comparison of graduate orthodontic clinic (GOC) and private practice orthodontics (PPO)—all case types	GOC (165) PPO (143)	GOC (33.0) PPO (27.5)
Christy et al[56]	GOC—all case types, bracket type, and compliance (2004–2006)	455	29.0

The current study showed that SureSmile treatment time was significantly shorter than conventional treatment time. The median SureSmile treatment time was 15 months, which is 8 months shorter than the median conventional treatment time of 23 months ($P < .001$). SureSmile patients also experienced four fewer median treatment visits than conventionally treated patients ($P < .001$).

Malocclusion type and treatment time

Of the records evaluated, 2,630 SureSmile records and 2,796 conventional records contained information on the type of malocclusion. The results demonstrated that Class I SureSmile patients experienced median care cycle lengths of 15 vs 22 months for Class I conventional patients; Class II SureSmile patients, 13 vs 22 months for Class II conventional patients; and Class III SureSmile patients, 16 vs 24 months for Class III conventional patients. For all types of malocclusions, SureSmile patients experienced significantly shorter care cycles than conventionally treated patients ($P < .001$). Previous studies indicate that Class I patients usually experience shorter treatment durations than Class II and III patients.[2,37,38,57,58] Surprisingly, Class II SureSmile patients experienced a shorter median treatment time than Class I SureSmile patients. Possible reasons for this finding include the fact that mild dental Class II types were included in the Class II category and that Class I patients had more severe crowding than Class II patients.

Patient age and treatment time

Of the records evaluated, 2,236 SureSmile records and 604 conventional records included information on patient age. The results showed that the median treatment times for both SureSmile adolescents (16 months) and adults (15 months) were significantly less than those of conventionally treated adolescents and adults (both 24 months, $P < .001$). The current study did not find any significant differences between the treatment times of SureSmile adolescents and adults and conventionally treated adolescents and adults ($P < .001$). Similarly, Dyer et al[59] found no significant differences between the treatment times of conventionally treated adolescents and adults ($P < .05$).

Other treatment modalities and treatment time

The SureSmile patient records were not classified as extraction and/or surgical cases; therefore, the influence of extraction and/or surgery on the length of treatment time was not analyzed in the current study. Previous studies, however, have found that extraction does not contribute significantly to an extended care cycle.[56] Fink and Smith[3] concluded that the extraction of a single premolar, two premolars, and four premolars contributed to 0.9, 1.8, and 3.6 additional months of treatment, respectively. Based on the aforementioned research, it may be assumed that extraction therapy in SureSmile patients would add no more than 4 months of treatment time (19 months), which would still be considered shorter than the mean treatment time of extraction therapy in a conventionally treated patient (28.12 months).[3]

Attributes of SureSmile technology affecting care cycle

SureSmile provides an integrated digital technology platform that enables clinicians to diagnose, plan, and design a customized therapeutic solution in the form of a prescription archwire for the patient. The components of SureSmile technology that may impact the length of the care cycle are discussed below.

3D imaging. SureSmile's 3D-imaging environment allows for improved spatial visualization, localization, and measurement of the dentition in all three planes of space. Bouwens et al[60] noted a significant difference between root angulation measurements from panoramic and 3D cone beam computed tomography (CBCT) images. That research found panoramic images to be distorted and therefore unreliable as a means of assessing tooth angulations and visualizing roots. Similarly, Okumura et al[61] and Kattan et al[62] determined that 3D virtual imaging provides a more precise display of morphologic features than 2D imaging systems and is potentially useful for routine treatment diagnosis.

Decision support system. SureSmile provides a robust, interactive decision support system driven by simulations. Through simulations, a clinician can visualize and validate the mental model of a plan with regard to treatment position.[63] Furthermore, the treatment plan can be designed interactively with the patient. Almog and Sanchez[64] demonstrated that computer-imaging simulations provide patients with a better understanding of proposed treatment plans. Morisky et al[65] demonstrated that better-informed patients generally adhere to treatment protocols more diligently, which favorably impacts the care cycle. Morisky et al[65] randomly assigned patients into two groups, a special intervention group composed of well-informed patients and a usual care control group, and found that the special intervention group experienced significantly higher levels of adherence to medical protocols than the usual care group (68% vs 38%, $P < .001$).

The SureSmile decision support system also allows for interprofessional collaboration since clinicians share their treatment plans with and seek clinical advice from one another. Both patient-clinician and interprofessional collaboration may minimize the disconnection in treatment objectives.[66]

Integrated clinical pathway. SureSmile software has built-in workflow automation and standardized checklists that provide a framework for the sequential management of patient care. Wolff et al[67] showed that the incorporation of checklists in clinical pathways results in improvements in the quality of patient care and builds reliability. His study also showed a positive correlation between the clinical pathway program and patient compliance. Furthermore, Hales and Pronovost[68] determined that the use of checklists improves the delivery of patient care and controls for error.

Robotic technology. The use of conventional appliances largely requires iterative changes to bracket position coupled with archwire bends, which prolongs care.[69,70] Studies on the reliability of conventional straight-wire appliances reveal that bracket slots have relatively poor tolerances, which may lead to imprecise tooth movement and add to treatment time. Conversely, a predefined plan drives the design of the SureSmile customized prescription archwire. The angular and torsional bends of the robotically bent archwire are precise to ± 1 degree and linear bends are precise to ± 0.1 mm.[33] The coupling of the clinician's plan and the prescription archwire overcomes the reactive elements of orthodontic care and enhances the reliability of appliance design. In turn, the movement of the dentition is more directed, potentially resulting in a shorter care cycle.

Practitioner experience. This investigation did not study the impact of the clinician's skill and the learning curve on the length and quality of treatment. Numerous studies in the medical arena have demonstrated an association between cumulative experience and improved performance using new technologies in health care. This is to be expected with the use of SureSmile technology as well. SureSmile technology in itself is not a magic bullet. It is only an enabling technology. Successful treatment outcomes can only be achieved in a timely manner when care is driven by an expert who has accumulated experience through deliberate practice.[71–74]

Limitations. While the number of records used for this analysis is quite robust, a substantial number of records lacked information that could have provided additional value to the current study. Furthermore, the records were collected from multiple practices that were not calibrated in terms of data collection, which could impact the accuracy of the provided variables, such as malocclusion type. A means of addressing the sometimes imprecise and incomplete nature of records is the establishment of a consistent method of data classification and entry.

Future studies. To further clarify the impact of SureSmile technology on patients, further studies must be conducted. Variables such as degree of case difficulty, nature of treatment, bracket type, practitioner experience, practice location, and reliability of appliance systems must be considered as influences on treatment time. A randomized, prospective clinical study of SureSmile vs conventional treatment would be an important second step in understanding the efficiency and effectiveness of SureSmile. Additionally, studies evaluating the impact of each unique clinical pathway of SureSmile technology as well as the integrated process itself are necessary.

CONCLUSION

This study determined the efficiency of SureSmile vs conventional treatment in terms of treatment time and additional variables that influence treatment time. On the basis of the results of this study of 12,335 patients from 142 SureSmile orthodontic practices, the following statistically significant ($P < .001$) conclusions may be drawn:

- SureSmile patients experienced a median treatment time of 15 months, which is 8 months less than that of conventional patients (23 months).
- SureSmile patients experienced a median treatment visitation period of 14 visits, which is a period of four fewer visits than that of conventional patients (18 visits).
- Class I, II, and III SureSmile patients experienced care cycles 8 to 9 months shorter than those of Class I, II, and III conventional patients.
- Class II SureSmile patients experienced shorter care cycles than Class I SureSmile patients, and Class III SureSmile patients experienced the longest care cycles in the SureSmile patient group.
- SureSmile adolescents and adults did not experience statistically significant differences in treatment time.

DISCLOSURE

Dr Rohit C.L. Sachdeva has financial interest in OraMetrix, the company behind the SureSmile treatment concept. The second and fifth authors, Dr Sharan L.T. Aranha and Nikita S. Sachdeva, are employed by OraMetrix.

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