



Scoliosis surgery in social media: a natural language processing approach to analyzing the online patient perspective

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Abstract

Purpose The purpose of this study is to analyze posts shared on Instagram, Twitter, and Reddit referencing scoliosis surgery to evaluate content, tone, and perspective.

Methods Public posts from Instagram, Twitter, and Reddit were parsed in 2020–2021 and selected based on inclusion of the words ‘scoliosis surgery’ or ‘#scoliosissurgery’. 100 Reddit posts, 5022 Instagram posts, and 1414 tweets were included in analysis. The Natural Language Toolkit (NLTK) python library was utilized to perform computational text analysis to determine content and sentiment analysis to estimate the tone of posts across each platform.

Results 46.4% of Tweets were positive in tone, 39.4% were negative, and 13.8% were neutral. Positive content focused on patients, friends, or hospitals sharing good outcomes after a patient’s surgery. Negative content focused on long wait times to receive scoliosis surgery. 64.7% of Instagram posts were positive in tone, 16.3% were negative, and 19.0% were neutral. Positive content centered around post-operative progress reports and educational resources, while negative content focused on long-term back pain. 37% of Reddit posts were positive in tone, 38% were negative, and 25% were neutral. Positive posts were about personal post-operative progress reports, while negative posts were about fears prior to scoliosis surgery and questions about risks of the procedure.

Conclusion This study highlights scoliosis surgery content in social media formats and stratifies how this content is portrayed based on the platform it is on. Surgeons can use this knowledge to better educate and connect with their own patients, thus harnessing the power and reach of social media.

Level of evidence IV.

Keywords Social media · Scoliosis surgery · Natural language processing · Computational text analysis

Introduction

The Internet and social media offer new resources for patients and their caregivers to learn about their medical conditions and to connect with others going through the same experience. At its best, social media has the potential to better inform patients and sustain their mental health through supportive online communities. However, this new media environment may also lead to misinformation, anxiety and poorly informed decision-making for patients and their

caregivers. For congenital and pediatric conditions such as scoliosis, these concerns are heightened, as both the child and parents may resort to online forums for information. In fact, according to a 2019 study, 69% of parents of children with scoliosis reported using the Internet to research their child’s condition [1]. As a result, it is vital for the orthopedic surgery community to understand these new sources of patient education and potential misinformation.

When it comes to scoliosis, the Internet and social media platforms currently represent high volume, but often low quality, sources of medical knowledge. Despite exponential growth in Internet-based information on scoliosis from 2005 to 2012, the overall quality of the information remained poor in 2012, according to a review of the top 100 websites generated from the five most popular search engines using the keyword “scoliosis” [2]. Similarly, a

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review of the first 100 pages on Facebook yielded poor information about scoliosis in a 2015 study [3]. These findings are important for orthopedic surgeons to understand so that they can better anticipate questions from patients and their caregivers, as well as dispel commonly held misbeliefs. Physicians can better communicate and manage patient expectations when they have insights into the information their patients and caregivers are accessing outside the clinic.

In the era of “Big Data” and natural language processing (NLP), clinicians can, for the first time, summarize popular opinion and provide epidemiological surveillance in real time and at scale. Social media analysis has been used as a predictive tool in diverse areas of research, ranging from vaccine hesitancy to chronic disease [4, 5]. Social media analysis has also been used as a tool to project anticipated case volume and seasonal trends of disease [6, 7]. Orthopedic surgeons can leverage social media as a new channel to communicate with patients, share accurate public health information, and build their personal reputations and practices. Particularly during the COVID-19 pandemic, these social media platforms provide opportunities for virtual networking among orthopedic surgeons to share research publications and best practices.

Social media, however, are not a monolith. There is a mosaic of platforms, each with their own unique audience and online culture. A 2017 review of pediatric orthopedic surgeons and their scoliosis patients in California identified a possible disconnect between the two populations. While surgeons were far more likely to share information about their practice on the professional networking site LinkedIn, patients and their families were far more likely to use other platforms [8]. Consequently, the present study seeks to review three popular platforms—Twitter, Instagram, and Reddit—and contextualize information related to scoliosis surgery. Using text-scraping algorithms, this study aims to highlight common themes in the online conversation about scoliosis surgery so that the orthopedic surgeon can interpret these emerging trends in patient education. The goal of this study is to assess how patients are utilizing social media for the topic of scoliosis surgery across three major platforms and comparing the similarities and differences between them.

Methods

Three social media platforms—Twitter, Instagram, and Reddit—were utilized for this analysis. Natural language processing algorithms were utilized to analyze the tone and content of the posts from each platform. Statistical analyses were conducted to compare the outcomes.

Twitter

Public Twitter data were collected using Twitter’s public Application Programming Interface (API) [Twitter, Inc.]. Tweets were included if they were English language and contained #ScoliosisSurgery or the words ‘scoliosis surgery’. Tweets were collected from November 2020 to April 2021.

Instagram

Public Instagram data were collected using Instagram’s API through the third-party vendor Picodash [Picodash, Inc.]. Instagram posts were included if they were English language and contained #ScoliosisSurgery in the caption. Posts collected dated from 2018 to 2020.

Reddit

Public Reddit data were collected using Reddit’s API [Reddit, Inc.]. Posts were included from the r/ScoliosisSurgery subreddit (a sub-forum within Reddit). Posts were excluded if they were not in English. Posts collected were from the year 2020.

Natural language processing

Word frequency analysis was performed on all sets of data to assess the most common words, word pairs, and 3 + word sequences in the posts. Word frequency analysis is a subset of computational text analysis that allows users to ascertain the context included in given word excerpts. This analysis package is able to parse out filler words to assess the main themes in a given text. This process allowed for an overall assessment of the content of the social media posts.

Natural language processing was also used for additional assessments of content. Factors such as the perspective of a post—i.e., that of the patient, family/friends, or organization—were obtained via the computational text analysis aspect of natural language processing. References to specific healthcare providers were also identified using computational text analysis to determine which posts included “Dr. ___”.

To evaluate the overall tone of each post, a natural language processing technique called sentiment analysis was utilized. The sentiment analysis package used in this study was “Valence Aware Dictionary and sEntiment Reasoner” (VADER), a package that is built into the Natural Language Toolkit (NLTK) library in python. VADER sentiment analysis is able to parse written prose to give scores that represent tone to a sentence or group of sentences. These tone scores

are calculated by the algorithm's analysis of the actual words used as well as the context they are used in. VADER relies on a dictionary of specific and common English words that retain inherent positive or negative qualities. The dictionary was developed by having ten independent human raters—who were trained and quality checked for inter-rater reliability—assign scores to each word in the dictionary ranging from -4 to +4, with 0 representing a neutral sentiment. VADER then takes the inputted sentences, scans for these specific words, and sums up and normalizes the scores to between -1 to +1, where -1 indicates the most negative sentiment and +1 indicates the most positive sentiment. The VADER package is able to take sentences or passages of text as inputs and output a compound score based on positivity or negativity of specific words, while utilizing equations to account for punctuation, capitalization, and word modulators. VADER sentiment analysis was used on each social media post collected to assign a sentiment score representing its overall tone. In the context of this study, a post with a positive tone could represent a patient sharing a good outcome or a favorable viewpoint of scoliosis surgery or a patient sharing a good review of a particular surgeon or procedure. On the other hand, a post with a negative tone could represent a patient sharing a bad outcome or negative viewpoint related to scoliosis surgery or a negative review of a particular surgeon or procedure. A post with a neutral tone would most typically be a clinically related question or impersonal educational material about scoliosis surgery.

Cross-platform comparison

The analysis of variance test for significance was used to compare differences in sentiment scores of the posts across the three platforms. The chi square test was used to compare differences in proportions of positive vs. negative vs. neutral-toned posts between each platform, two at a time.

Multivariate logistic regression

Multivariable logistic regression was used to assess the association of specific topics—represented by the most common words and word-pairs—with positive or negative tone of the overall post. The most common words and word-pairs used in posts from Twitter and Instagram, identified during

frequency analysis, were included in the multivariate logistic regression. Reddit posts were excluded from the multivariate regression analysis due to their limited sample size as compared with the other two groups of posts.

Results

Overall, a total of 1414 Tweets, 5022 Instagram posts, and 100 Reddit posts were obtained during the data collection time period based on inclusion and exclusion criteria (Table 1).

Twitter

Of the 1414 collected Tweets, 1125 (79.6%) were written by the patient and/or about the patient perspective, and were included in further analysis. Of the 1125 Tweets analyzed using NLP, 46.4% were positive in tone, 39.4% were negative, and 13.8% were neutral. In this study, we defined the most positively toned tweets as having a sentiment score > 0.5 and the most negatively toned tweets as having a score < -0.5. Among the most positive tweets (sentiment score > 0.5; 314 tweets), the content mainly focused on patients sharing favorable outcomes after their scoliosis surgery, how the result of this procedure has improved their quality of life over time, and effective treatments. Other areas of content that were represented in the most positive tweets included body confidence and “demystifying” scoliosis surgery in terms of improving patient knowledge. Among the most negative tweets (sentiment score < -0.5; 227 tweets), the vast majority of content focused on long wait times to receive scoliosis surgery or chronic back pain experienced before undergoing surgery (Fig. 1).

Of all tweets collected, about 9.8% were about pain, thus noting a potentially important topic discussed on the platform. Of all tweets collected, 15.3% referenced a specific doctor by name.

Instagram

Out of the total collected Instagram posts, 4179 were about the patient perspective (83.2%) and thus included in further sentiment analysis. Of the 4179 Instagram posts analyzed

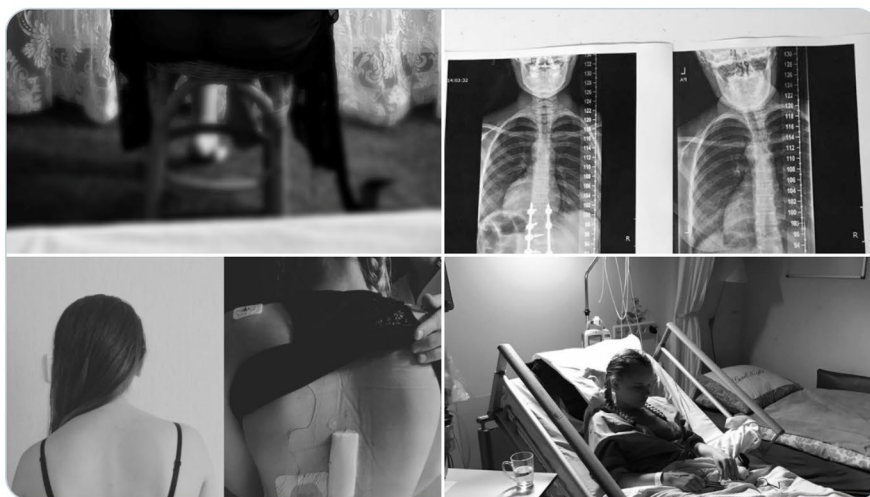
Table 1 Summary of collected social media data

	Twitter	Instagram	Reddit
Total # of posts collected	1414	5022	100
% of posts from or about the patient perspective	79.6%	83.2%	100%
% of posts that mention a specific doctor	15.3%	22.8%	10.0%
Timeframe	November 2020–April 2021	2018–2020	2020

Fig. 1 Example of a positive (a) and negative (b) scoliosis surgery-related Tweet, anonymized to exclude username

(a) today three years ago since my scoliosis surgery..

man where do i even start. this will always be one of the most emotional days ever. getting rid of my chronic backpain & the body ive always hated. im so grateful for this day forever. #scoliosis



6:14 PM · Mar 11, 2021 · Twitter for iPhone

1 Retweet 39 Likes



(b) How can children who suffer from Scoliosis and urgently require surgery just be left. Can't even get an urgent appointment. Rapid progressive scoliosis cannot be left. If left untreated a 2 stage surgery is required. How is this having the patients best interest at heart !

6:45 AM · Jan 6, 2021 · Twitter for iPhone



using NLP, 64.7% were positive in tone, 16.3% were negative, and 19.0% were neutral. The positive posts' content centered around post-operative progress reports, educational resources, and rehabilitation. Progress updates at specific recovery timepoints were posted via pictures or video. The negative content was focused mostly on long-term back pain due to scoliosis. Among the most positive posts (sentiment score > 0.5 , 2326 posts), the majority of content was about educational resources, progress with rhetoric such

as “journey”, perseverance with rhetoric such as “fighter”, “warrior”, etc., based on our frequency analysis of words, bigrams, and trigrams. Among the most negative posts (sentiment score < -0.5 , 413 posts) the content was mainly about chronic back pain. Of note, there was a large amount of reposting, indicated by one of the most common words used in the Instagram captions being “reposting” or “resharing”. Typically, these posts were made in the form of sharing educational materials created by other accounts or sharing other

people’s stories and relating them to one’s own battle with scoliosis and progress after surgery. Finally, 22.8% of all posts referenced a specific doctor.

Reddit

Of the collected Reddit posts, all were about the patient perspective and thus included in further analysis. 37.0% were positive in tone, 38.0% were negative, and 25.0% were neutral. The most positive Reddit posts were about personal post-operative progress reports. The most negative Reddit posts were about fears prior to scoliosis surgery and questions relating to the risks of the procedure.

Cross-platform comparison

When comparing sentiment scores of posts between Twitter, Instagram, and Reddit, we found a significant difference across the 3 platforms using an ANOVA test (p value < 0.001). When comparing proportions of positive vs. negative vs. neutral sentiment scores of posts from Twitter and Reddit, no significant difference was found (p value = 0.303). When comparing proportions of positive vs. negative vs. neutral sentiment scores of posts from Twitter and Instagram, a significant difference was found (p value < 0.001). In addition, a significant difference between proportions of positive, negative, and neutral sentiment scores of posts was found between Instagram and Reddit (p value < 0.001) (Fig. 2).

Multivariate logistic regression

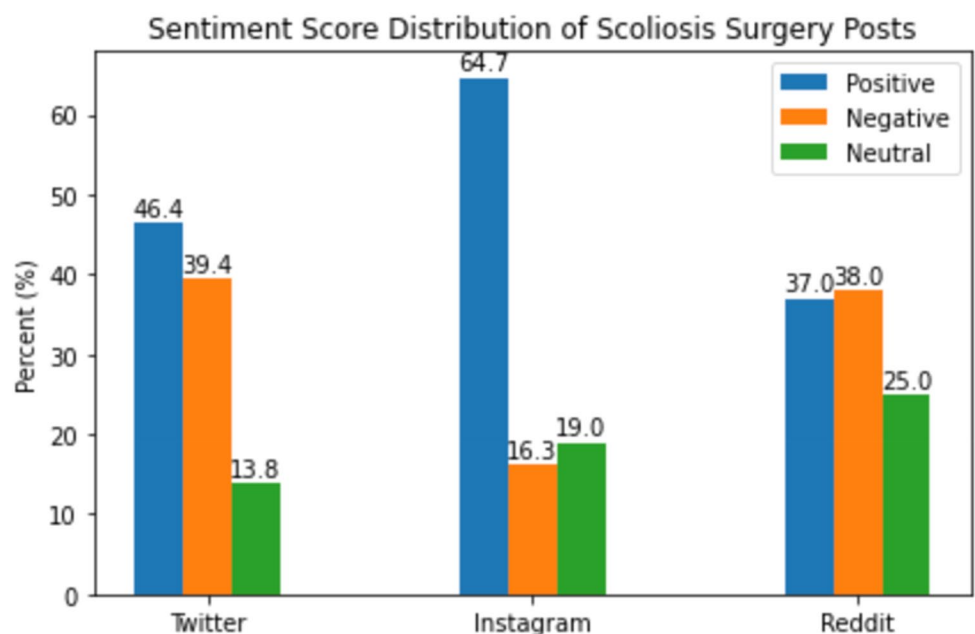
Multivariate logistic regression was used to evaluate which of the most common words and word-pairs used in Twitter and Instagram posts were significantly associated with positive sentiment posts. Of the most common words and word-pairs identified, several were determined to be independent predictors of a post being positively toned.

In the Instagram post analysis, the following were identified as independent predictors of a post having a positive sentiment score: ‘body’, ‘reliable’, ‘progress’, ‘resources’, ‘education’. This result highlights the importance of these topics among Instagram users who are posting about

Table 2 Regression analysis to look at association of the inclusion of common words used in Instagram posts and sentiment score (tone) of the overall post

Word	OR	95% CI	<i>p</i> value
Suffer	1.19	0.43–3.34	0.73
Delay	2.43	0.22–26.82	0.47
Effective	2.58	0.82–8.16	0.11
Scar	1.05	0.76–1.44	0.78
Clothes	3.14	0.85–11.56	0.08
Body	2.70	2.13–3.42	<0.001
Reliable	97.56	24.15–394.05	<0.001
Pain	1.05	0.90–1.22	0.57
Chronic	0.86	0.53–1.40	0.55
Progress	8.30	3.97–17.37	<0.001
Resources	9.71	1.21–77.80	0.03
Education	3.62	1.17–11.17	0.02

Fig. 2 Distribution of sentiment analysis results across each social media platform



scoliosis surgery. No words were found to be independent predictors of a post having a negative or neutral sentiment score (Table 2).

In the Twitter posts analysis, the following were identified as being predictors of a post having a positive sentiment score: ‘clothes’, ‘hope’, ‘effective’, ‘help’. On the other hand, the following were identified as independent predictors of a post having a negative or neutral sentiment score: ‘pain’, ‘months’. This highlights the impact of this content in positive and negative tweets. (Table 3).

Discussion

This study investigates social media use in scoliosis surgery, revealing a sparingly studied avenue for understanding the patient perspective of their surgical experience. Before the digital age, patient discussions about upcoming or prior surgeries were conducted either in physician offices or by word of mouth with friends and family. In this day and age, social media can reveal a new perspective on how patients are talking about their scoliosis surgeries and relaying that information to their social network. This kind of information can aid surgeons in patient education, engagement, and pre-procedural counseling. With healthcare increasingly becoming more patient-centered, our study can offer a “behind-the-scenes” look into how patients are perceiving scoliosis surgery and reveal the main topics of both their satisfaction and concern.

Across Instagram, Reddit, and Twitter, our study found that the most positively toned content was about patients sharing their progress reports after scoliosis surgery as

well as general educational material. This result aligns with previously noted trends of patients turning to Internet resources for education [9, 10], as well as for a community related to their medical condition [11]. The results show that these social media platforms are utilized by many scoliosis patients to share their experiences with their surgery, thus providing surgeons a new way to understand their patients’ more personal perspectives on clinical outcomes.

In addition, the prevalence of educational material content across the different platforms not only shows another way scoliosis patients utilize these platforms, but also reveals to surgeons a potential avenue to utilize for patient education and engagement. The educational content that patients can access from the three social media platforms analyzed in this study are twofold: scoliosis surgery patient experiences and scoliosis surgery pre- and post-operative clinical content. The patient experiences aspect to the educational material are the stories of real patients that are shared on these platforms. Patients thinking about getting scoliosis surgery can learn from the post-operative progress reports, pre-operative tips, and surgical experiences that get posted online by other scoliosis surgery patients. It is often more powerful for potential patients to hear the stories and advice from prior patients, rather than a generic paper brochure from their orthopedic surgeon’s office. Based on our results, potential scoliosis patients can turn to social media for both personal stories from prior patients and clinical content that could inform their decision. Therefore, there is potential benefit for surgeons to increase their social media engagement to better serve the scoliosis community, especially when it comes to those who had or are thinking about surgery.

The most common topics among negatively toned posts were about failure to deliver timely access to scoliosis surgery, chronic back pain, as well as the risks of surgery. Surgeons can use this knowledge to deepen their understanding of scoliosis patient concerns to better address them in their clinical practice in the future.

As stated previously, social media is not a monolith. Since its inception in the early 2000s, a plethora of platforms have been developed, each with the potential to be used in distinct ways. When assessing social media’s involvement in a medical topic, it is important to highlight this distinction between platforms to best assess its usage. When we break our analysis down to platform-specific results, we see differences between Twitter, Instagram, and Reddit in terms of their use for scoliosis surgery specifically.

Instagram had the largest percentage of positive posts. This aligns with the fact that Instagram is inherently more centered around personal stories and progress updates, with the user interface designed to share pictures and videos about major life events. Instagram’s most common scoliosis surgery-related content was about these personal progress posts and recovery stories, as well as educational

Table 3 Regression analysis to look at association of the inclusion of common words used in Tweets and sentiment score (tone) of the overall Tweet

Word	OR	95% CI	<i>p</i> value
Suffer	3.05	0.66–14.13	0.15
Wait	0.70	0.28–1.77	0.45
Delay	0.20	0.02–1.62	0.13
Pain	0.32	0.13–0.78	0.012
Years	0.87	0.54–1.41	0.57
Months	0.11	0.01–0.81	0.03
Help	4.81	2.93–7.90	<0.001
Effective	29.45	3.71–233.59	0.0014
Hope	12.99	5.05–33.40	<0.001
Scar	0.48	0.11–2.12	0.33
Clothes	12.91	2.13–78.23	0.0054
Body	2.37	0.93–6.09	0.072
Back-pain	0.40	0.04–3.97	0.43
Chronic-pain	2.38	0.39–14.37	0.35

resources. As such, patients may be using Instagram as a mechanism to gather information on recovery after surgery.

Twitter had the largest proportion of negative posts, which aligns with some of the platform's most displayed scoliosis surgery-related content: long wait times and chronic back pain. Other common content on Twitter included body image and effective treatments. This outcome highlights the importance that timeliness of access to surgery has among scoliosis patients. In addition, these data could indicate that chronic back pain and effective treatments for it may be strong factors in a patient's decision of whether or not to have scoliosis surgery. As such, surgeons should pay special attention to counseling patients on the treatment options to alleviate chronic pain.

Reddit had a large percentage of neutral-toned posts. This outcome aligns with the fact that Reddit's content focused almost entirely on clinical questions and progress reports/updates told from the perspective of the patient. This reveals Reddit as a major source of clinical questioning and answering for scoliosis surgery patients. Physicians can take advantage of this forum and use the platform to connect with patients and give them correct clinical answers to their questions and concerns.

The regression analysis revealed that overall, pain and delays were found to be a major topic of disapproving discussion across the 3 platforms, particularly on Twitter. With this information, surgeons can focus on sharing treatment plans for chronic pain management, perhaps by implementing a social media campaign. In addition, surgeons can consider ways to be more transparent and upfront about their availability and timelines for potential patients. Based on the evidence from this study, this kind of campaign would be most effective on Twitter. Moreover, patient education is important on all platforms, but especially on Instagram. As such, surgeons would benefit from sharing more patient progress reports on Instagram to educate their new patients, or refer new or potential patients to their former patient's posted progress reports. Finally, surgeons can use Reddit to engage with patients by directly answering their clinical questions. They may also benefit from using questions on scoliosis surgery content from all three platforms to improve patient education in their own clinics by limiting oversight of topics that patients may be inquiring about once they leave the office. The low percentage of specific physicians indicated by name may indicate an underutilization of the platform for patient engagement. Since people are increasingly relying on social media as a source of information and recommendations, these platforms are important places for doctors to recognize as information sources and question/answer forums for their patients.

Limitations

Limitations of this study include the fact that hashtags were used to pull public data from Twitter and Instagram, and not every user on either platform includes hashtags in their posts. Therefore, private posts or posts that did not include selected hashtags were not included. Another limitation that exists is that the patients who post on social media cannot represent the totality of the scoliosis population, because only a percentage (73%) of total U.S. adults are utilizing one or more forms of social media in the first place [12]. For this reason, a fraction of the total scoliosis surgery patient population will not be represented in this study.

In addition, there may be a positivity bias among included posts due to the fact that users tend to post more positive-focused content online about their lives [12]. On the other hand, a negative bias may exist on certain platforms, such as Twitter and Reddit on which approximately 38–39% of posts were negatively toned. On these platforms, users may be more willing to share negative experiences or complaints due to a degree of anonymity that exists in the virtual world of social media accounts. Another limitation of this study is the fact that natural language processing methods were used to identify content and tone of each post. While natural language processing has proven accuracy for predicting content and sentiment of texts [13], there is a level of inaccuracy that must be acknowledged.

Conclusion

Looking at how scoliosis surgery is represented on social media can give orthopedic surgeons a new method of identifying patient perception of this particular procedure. With the exponential rise in social media use over the past decade, these data represent a largely untapped reservoir of information. In addition, not only is social media large in user numbers, but it is also nuanced—each platform is used for different reasons, depending on the content being discussed. This analysis explains how patients are utilizing three major social media platforms to talk about scoliosis surgery and stratifies how this content is portrayed based on the platform it is on. Surgeons can use this knowledge to better educate and connect with their own patients, thus harnessing the power and reach of social media. Considering their widespread use, Instagram, Twitter, and Reddit are powerful tools that can be used to communicate important pre- and post-surgical information to patients receiving or interested in scoliosis surgery.

Author contributions CLD: contributed to conception/design of work, analysis/interpretation of data, drafted the work, approved version to be published, agrees to be accountable for all aspects of the work. VA: contributed to conception/design of work, critically revised the work, approved version to be published, agrees to be accountable for all aspects of the work. JET: contributed to analysis/interpretation of data, critically revised the work, approved version to be published, agrees to be accountable for all aspects of the work. CPB: contributed to analysis/interpretation of data, critically revised the work, approved version to be published, agrees to be accountable for all aspects of the work. SDP: contributed to analysis/interpretation of data, critically revised the work, approved version to be published, agrees to be accountable for all aspects of the work. JSK: oversaw the project, critically revised the work, approved version to be published, agrees to be accountable for all aspects of the work. SKC: oversaw the project, revised the work, approved version to be published, agrees to be accountable for all aspects of the work.

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Availability of data and materials All data is publicly available social media data.

Code availability Publicly available python packages and third party web scrapers were used. Custom code was also used.

Declarations

Conflicts of interest The authors have no relevant financial or non-financial interests to disclose.

Ethics approval This is a retrospective data study and thus conforms to all ethical standards required for a retrospective analysis article.

Consent to participate Not applicable.

Consent for publication All authors of this paper give consent for publication.

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