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Understanding Patient Attitudes Toward Multifocal Intraocular Lenses in Online Medical Forums Through Sentiment Analysis

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Abstract

Multifocal intraocular lens implants (IOLs) are a premium option for cataract surgery which patients may purchase to achieve improved spectacle-independence for near vision but may have trade-offs with visual quality. We demonstrate the use of sentiment analysis to evaluate multifocal lenses discussed on MedHelp, a leading online health forum. A search for "multifocal IOL" was performed on MedHelp.org on November 1, 2016, yielding relevant patient posts. Sentiment analysis was performed using IBM's Watson, which extracted 30,066 unique keywords and their associated sentiment scores from 7495 posts written by 1474 unique patient users. Keywords associated with monovision, monofocal, and toric lenses had positive mean sentiment, significantly higher than for keywords associated with multifocals, which had negative mean sentiment ($p<0.001$, ANOVA). Many keywords represented complaints and were associated with negative sentiment, including glare, halo, and ghosting. Sentiment analysis can provide insights into patient perspectives towards multifocal lenses by interpreting online patient posts.

Keywords: Natural Language Processing, Multifocal Intraocular Lenses, Social Networking

Introduction

Cataract surgery is the most commonly performed surgery in the United States, with nearly 4 million surgeries performed per year [1]. Cataract surgery restores clarity of vision by replacing the natural, cloudy lens of the eye with a clear intraocular lens (IOL) implant. Standard monofocal IOLs are designed with a single dioptric power enabling sharp vision at a pre-determined target distance. Most patients desire a distance target, resulting in a need to wear reading glasses to correct presbyopia and achieve clear vision for near- or intermediate-distance tasks. Interest in sharp spectacle-free vision at a range of target distances has paved the way for the development of premium presbyopia- and astigmatism-correcting advanced technology IOLs. Some of these lenses have been designed to mimic accommodation (Crystalens), or provide clear vision at multiple predetermined focal points simultaneously via concentric rings of multiple dioptric powers (multifocal IOLs), or, more recently, offer extended depth of focus across a more continuous range of distances (Tecnis Symfony). These lenses have been promoted as a method of achieving spectacle independence. However, patients must bear the cost of this premium IOL option out-of-pocket as insurance companies do not reimburse for the extra cost, which averages over two thousand dollars per eye in the US [2].

While multifocal and extended depth of focus IOLs (hereafter referred to collectively as multifocal IOLs) may provide a higher chance of acceptably clear spectacle-free vision, they have been reported to be associated with glare, halos, and reduced contrast sensitivity due to their complex optical design, particularly in the earliest generation models [3]. Such side effects can be potentially disabling and sometimes result in patients pursuing a second, riskier, surgery to exchange the implanted intraocular lens [4]. Achievement of improved visual acuity is not always correlated with patient satisfaction with cataract surgery, which rather may relate more to meeting patient expectations surrounding visual functioning [6]. Thus, understanding the expectations and outcomes that matter most to patients is imperative. Given the potentially high patient costs of multifocal lenses, both financial and otherwise, thorough assessment of patient-reported outcomes are important in guiding patients and physicians in their choice of lens implant and may become an important additional endpoint for clinical trials of future generations of IOLs.

MedHelp.org is one of the largest online medical communities where patients may engage in health-related discussions, with over 10.8 million discussions since its inception in 1994. From 2007 to 2014, there was an active eye care "expert" moderated sub-forum operated in collaboration with the American Academy of Ophthalmology (AAO) where members of the community could post questions to be answered by volunteer ophthalmologists. A separate eye care "community" sub-forum is also ongoing. Together, they provide a rich source of unstructured, free-text data on the patient experience with eye health and disease [7].

Natural language processing (NLP) is a rapidly advancing field within biomedical informatics that includes sentiment analysis, a discipline concerned with identifying the sentiment or position of a text towards a particular topic, classified on a scale indicating positive, negative or neutral sentiment. NLP further allows the extraction of structured concepts from free text, such as clinical concepts. With the concurrent increase in computing power and explosion in sources of unstructured text data, NLP and sentiment analysis techniques have been applied to many problems including computing consumer satisfaction metrics, monitoring social media, and forecasting financial markets, but their use is relatively nascent in healthcare. Emerging literature has suggested that patient online social media posts can be well-correlated to more formal measures of patient satisfaction, such as the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey [8]. IBM Watson, one of the most widely-recognized artificial intelligence services, has many NLP capabilities trained to extract concepts, entities, keywords, and sentiment from English language texts and has been used in healthcare to develop decision-support aids in fields as diverse as oncology [9] and radiology [10].

In this study, we sought to apply IBM Watson's NLP and sentiment analysis algorithms towards unstructured text data in MedHelp.org forum posts related to cataract surgery lens options, particularly multifocal IOLs. The goal was to identify the most popular keywords and clinical terms around multifocal IOLs used in patient discussions and their associated sentiment (positive or negative), as a generalized measure of patient satisfaction for each keyword category.

Methods

Data Source and Study Population

MedHelp.org includes an eye care "expert" forum operated by ophthalmologists (2007-2014) and an ongoing eye care "community" forum where patients discuss eye-related issues. Forums contain multiple discussion threads related to a particular topic originated by the initial user post, and each thread consists of multiple posts that are replies made by various individual users to the discussion of that topic.

A keyword search for "multifocal IOL" was performed on November 1, 2016 in the MedHelp.org eye health expert and community sub-forums, yielding the relevant discussion threads in these forums since website inception in 1994. We obtained the full text of the discussion threads, and individual posts of resulting threads were parsed for user, timestamp, and full text. Each user's profile was also analyzed for self-reported age, sex, and location information, if available. Physician profile pages on the site identified physician users, and their posts were excluded from sentiment analysis.

Natural Language Processing and Sentiment Analysis

Sentiment analysis was performed on the full text of each patient post using IBM's Watson proprietary artificial intelligence capabilities via the AlchemyLanguage application program interface (API) [11]. The public model of AlchemyLanguage is trained on English language newspapers and websites to extract concepts, entities, keywords, and sentiment. Each post was given an overall positive or negative sentiment score ranging on a continuous scale from -1 to +1, with the strength of sentiment represented by the magnitude of its numerical value. Neutral sentiments (neither positive nor negative) were assigned a score of 0. AlchemyLanguage also extracted user-generated keywords and phrases from each post and provided an associated sentiment score for each keyword or phrase for that post. Natural language processing was performed to group related keywords by converting to lowercase, removing punctuation, and stopwords (a, and, the, etc.), tokenizing (separating into distinct words, using the Treebank tokenizer [12]), and lemmatizing (transforming each word into its root word, such as making plurals singular, or transforming different forms of the same verb into a root verb, using the WordNet lemmatizer [13]). Keywords and phrases were further processed by string matching to group by clinical concept. Similar keywords and phrases were grouped by considering "IOL" and "lens" to be interchangeable. When IOL manufacturer/brand name were extracted together with the lens model as a keyword, these keywords were aggregated under the name of the lens model. Keywords mentioning "Tecnis Symfony" lenses were grouped into "symfony" whereas mentions of "Tecnis" without "Symfony" were grouped under "tecnis." If key phrases included "Crystalens" and "HD" then they were grouped under "crystalens hd" but if they mentioned "Crystalens" without "HD" they were grouped under "crystalens." All key phrases mentioning "restor", "mplus", "rezoom" were aggregated into groups, regardless of what additional accompanying words were included in the key phrase such as manufacturer (e.g., "Alcon ReSTOR" was grouped under "restor" and "Lentis Mplus" was grouped under "mplus"). If key phrases included both "multifocal" and "toric" they were grouped under "multifocal" but if only "toric" was mentioned then they were grouped under "toric." Key words and phrases associated with contact lenses were disambiguated from IOL lenses. After aggregation of common related keywords, the 250 most commonly identified keywords were examined in greater detail, from which were identified keywords representing multifocal, monofocal, and toric lenses as well as monovision and words that could be related to side effects, complications, or complaints to analyze in greater detail. A flow diagram summarizing the process of online post retrieval, sentiment analysis, and text processing is depicted in Figure 1.

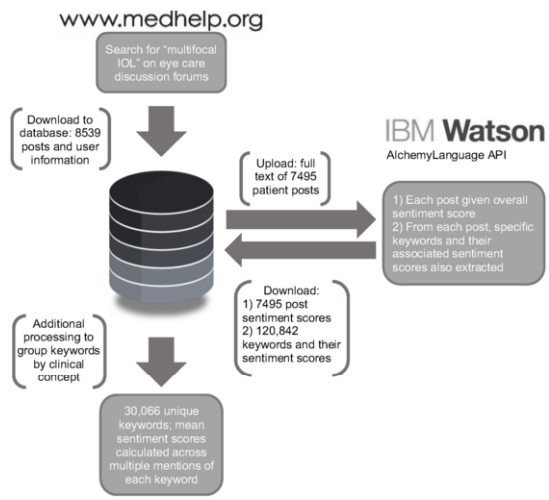

Figure 1 — Flow Diagram for Retrieval of Posts

Statistical Analysis

Mean sentiment scores and their standard deviations were calculated for each keyword across all resulting patient posts. One-way ANOVA was performed to compare mean sentiment scores between different groups of IOLs, which included monofocal, monovision (a strategy whereby each eye is implanted with a monofocal lens but with one eye targeted for clear distance vision and the other eye is targeted for near vision), toric (astigmatism-correcting), and multifocal. For the purposes of defining groups for ANOVA comparisons, the monovision group aggregated keywords "monovision", "minimonovision", "blended vision", and the multifocal group aggregated keywords "multifocal", "premium lens", "restor", "crystalens", "crystalens hd", "symfony", "rezoom", "tecnis", "mplus". Post-hoc Bonferroni comparisons were made to compare sentiment scores between groups.

We performed natural language processing using Python 2.6 (Python Software Foundation, Wilmington, Delaware) and the NLTK package version 3.2.1 (NLTK Project, Philadelphia, PA) [14]. Sentiment analysis was performed using IBM Watson via the AlchemyLanguage application program interface (API) (IBM, Armonk, NY) [11]. Statistical analysis was performed using Stata version 12 (Stata Corp, College Station, TX).

Results

Study Population and Search Results

A search for "multifocal IOL" on MedHelp.org identified 981 threads containing 8539 posts ranging from June 16, 1999 to October 31, 2016. Contributing to these posts were 1488 unique users, of whom 14 were physicians who contributed 1044 posts and 1474 were patients who contributed 7495 posts. Of the patient users, 547 (37.1%) self-identified as male, 536 (36.4%) self-identified as female, and 391 (26.5%) did not specify gender in their profile information. A total of 400 (27.1%) patient users specified an age in their profile information, which ranged from 19 to 87 years, with a mean age of 57.9 years (standard deviation 14.3).

Sentiment Analysis

Overall sentiment scores for patient posts ranged from -0.95 to 0.99, with a mean sentiment score of 0.07 (standard deviation 0.45) across all posts. A total of 120,842 specific keywords and phrases were extracted from all patient posts. Related keywords were grouped by syntax (plurals and singulars, conjugations of the same verb) and clinical concept (for example, "multifocal IOL" grouped with "multifocal lens"), yielding 30,066 unique keywords. Among the top 250 most commonly-occurring keywords were those associated with multifocal lenses and their individual models, standard monofocal lenses or monovision, and keywords that may be associated with complications or complaints (Figure 2).

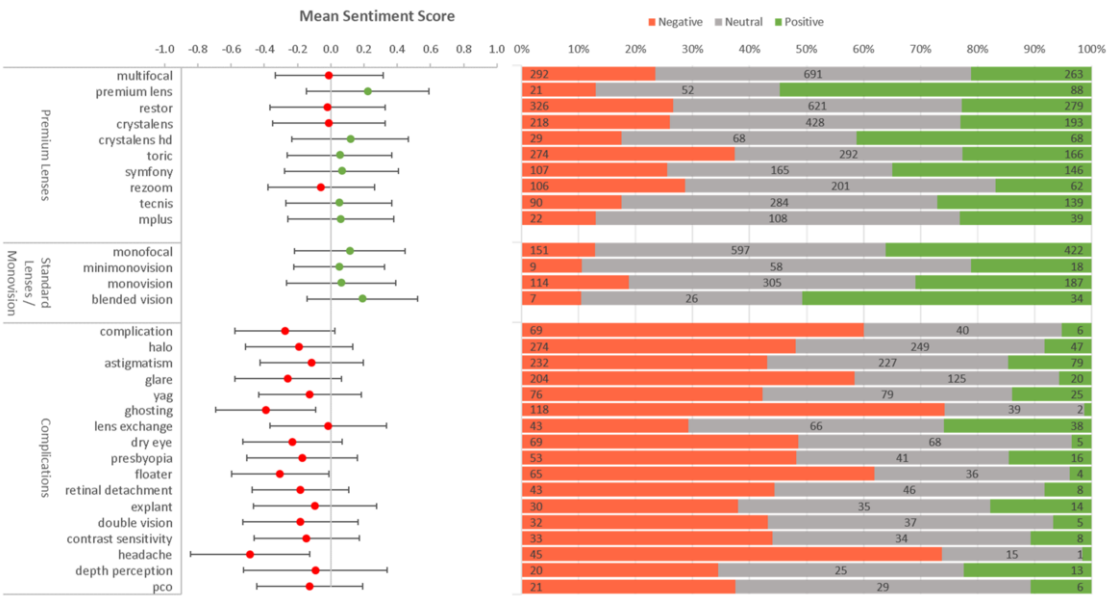

Figure 2 — Sentiment Towards Premium and Standard Cataract Surgery IOL Options and Cataract Surgery Side Effects

(Left) Mean sentiment is shown with standard deviation error bars for keywords related to premium lenses, standard monofocal lenses or monovision, and a variety of words related to cataract surgery complications, complaints, or side effects. Negative and positive mean sentiment are shown in red and green respectively. (Right) Proportion and number of positive, negative, and neutral sentiment instances for each keyword are shown in horizontal bar graph.

Sentiment analyses are displayed in Figure 2. Keywords associated with multifocal lenses (not including specific models) had slightly negative mean sentiment (N=1246, -0.010). Individual models of multifocal or premium lenses were commonly identified as keywords, with those most widely used in the US associated with a slightly negative mean sentiment (ReSTOR N=1226, -0.020; ReZoom N=369, -0.059; Crystalens N=839, -0.012), while newer lenses had more positive sentiment (Crystalens HD N=165, 0.117; Tecnis Symfony N=418, 0.065; Tecnis (non-Symfony) N=513, 0.048). Keywords associated with monofocal lenses had positive mean sentiment (N=1170, 0.11), as did keywords associated with monovision, a strategy whereby each eye is implanted with a monofocal lens but with one eye targeted for clear distance vision and the other eye targeted for near vision (monovision, N=606, 0.06; minimonovision N=85, 0.05; blended vision N=67, 0.19)

A wide range of keywords represented types of side effects or complaints by the patients and were associated with negative mean sentiment. The most common complaints included glare (N=349, -0.257), halo (N=570, -0.190), astigmatism (N=538, -0.115). Other complaints associated with very negative sentiment included ghosting (N=159, -0.392), floater (N=105, -0.305), headache (N=61, -0.485).

There was significant variation in sentiment score between four different IOL implantation strategies: monofocal, monovision, toric, and multifocal (including specific models of multifocal lenses) in ANOVA analysis (F-score [3, 7590]= 35.59, $p<0.001$) (Table 1). Post-hoc Bonferonni multiple comparison tests indicated that when compared to multifocal lenses, monofocal lenses ($p<0.001$), monovision ($p<0.001$), and toric ($p=0.024$) lenses all had significantly higher positive mean sentiment.

Table 1 – ANOVA for Sentiment Scores

Source of variation	df	Sums of Squares	Mean Square	F-Score	p-value
Between Groups*	3	11.98	3.995	35.59	<0.001
Within Groups	7590	851.94	0.1122		

*Monovision group aggregated keywords "monovision", "minimonovision", "blended vision". Multifocal group aggregated keywords "multifocal", "premium lens", "restor", "crystalens", "crystalens hd", "symfony", "rezoom", "tecnis", "mplus."

Discussion

Over 4 million cataract surgeries are performed annually in the US, with premium multifocal intraocular lens implants increasingly used to provide clear vision at multiple focal points. However, potential side effects of these new lenses are a concern, and information on patients' subjective experiences is not readily available. Mining eye-related discussion forums on the MedHelp online health forum, we found patient sentiment towards monofocal lenses was positive, while the sentiment towards multifocal lenses was mixed, but overall slightly negative, especially related to older models such as ReZoom. Furthermore, this approach also identified that newer multifocal lenses, such as Tecnis Symfony, were associated with more positive sentiment. Many side effects associated with multifocal lenses were mentioned in the forums, including glare and halos, as well as ghosting, double vision, and headaches – each associated with negative sentiment. The ability to identify patient concerns with emerging technology is essential to help guide both patients' and clinicians' treatment decisions.

Previous studies have not conclusively demonstrated a benefit in patients' general satisfaction with implantation of multifocal lenses compared to standard monofocal lenses, as overall patient satisfaction following cataract surgery is typically high in both groups [3]. However, studies suggest multifocal lenses are associated with greater reports of postoperative glare, halos, and reduced contrast sensitivity [3]. We found that sentiment towards multifocal lenses was not as positive overall as sentiment towards traditional monofocal lenses. However, when individual models of multifocal lenses were considered, newer lenses such as Symfony and Crystalens HD were associated with more positive sentiments than older lenses. The earliest available multifocal lenses such as ReZoom, Crystalens, and ReStor have been the most extensively studied, and concern for postoperative glare and halos with multifocal lenses is most reflective of these initial studies [3, 5]. As multifocal IOL design has advanced, a few studies have reported that newer IOL models may have fewer visual side effects [15–17] – consistent with our findings that sentiment towards the newer Symfony lens is more positive.

Previous studies have used a variety of questionnaires to measure postoperative satisfaction or visual function, either general visual functioning indices or more often scales developed specifically for a given study, designed to elicit reports of halos or glare [3]. In our analysis of unprompted patient online forum posts, halos and glare were among the most frequently expressed concerns, but we identified many other common concerns with associated negative sentiment including astigmatism, ghosting, dry eye, lens exchange, and double vision. Interestingly, lens exchange was associated with only slightly negative mean sentiment, nearly neutral, suggesting appropriate patient selection and perhaps good visual outcomes following lens exchange surgery. By contrast, mentions of headache, though not exceedingly common, were associated with very strongly negative sentiment.

This study has several limitations. We recognize that our analysis is limited in that it does not account for patient selection or expectations, relying on online forums, which are by nature anonymous, with limited data on users. Participation in online forums may vary by patient demographics, such that represented opinions may be skewed towards younger or more tech-savvy patients. Furthermore, there may also be considerable bias in online discussions, in that patients who are content with surgery may be less likely to post online than highly dissatisfied patients. Posts were limited to 2016 and prior period; however, it represents the dissemination of the key implants. Typographical or auto-correct errors, such as ReSTOR being typed and extracted as restore, were ignored. Users were not always specific regarding which model of lens they were referring to, so multiple models of similarly branded lenses (e.g. ReSTOR and ReSTOR low-add versions) were grouped for sentiment analysis. In addition, sentiment analysis using different algorithms may vary. Although we have utilized IBM Watson as one of the oldest and most recognizable artificial intelligence initiatives, limitations still exist in this approach. We have applied Watson's robust but proprietary general capabilities to the highly specific field of ophthalmology. Future work can improve upon this approach by training algorithms to recognize ophthalmology-specific entities and to distinguish preoperative questions from postoperative concerns. Future work to develop a more ophthalmology-specific model can address these issues.

However, despite these limitations, this study presents a novel application of natural language processing and sentiment analysis techniques to a non-traditional data source—online forum posts—in order to identify insights related to cataract surgery. This approach offers a relatively rapid and low-cost way of identifying many opinions from large groups of people on a particular topic, compared to traditional focus groups, which are labor-intensive and costly to assemble. Using this approach, the overall perception of emerging technology may be quickly surveyed to form an overall community sentiment or to identify unanticipated problems. Automated sentiment analysis may also be useful to supplement the depth and nuance of opinions obtained in focus groups with a broader sweep of opinions from larger populations, or to perform automated sentiment analysis on transcripts of focus group discussions to ensure important concepts are not overlooked. Alternatively, this approach may be utilized to analyze open-ended patient-reported outcomes collected in settings where the population is controlled, such as within the context of a clinical trial, where clinical outcomes are being measured simultaneously. Furthermore, although traditional questionnaires with Likert-scale ratings for specific outcomes allow standardized data analysis, other patient concerns may not be well captured. Using natural language processing to analyze unstructured, open-ended data has the advantage of revealing insights derived from patients' own language, and patient concerns that fall outside the confines of any particular questionnaire. These insights may be used to develop or refine patient-centered outcome measures to be more inclusive of diverse patient concerns, and to better target patient counseling efforts to address the most prevalent or highly impactful patient concerns. Despite the likely presence of some bias in online discussions towards dissatisfied patients, it is still worthwhile to investigate the sentiments of a vocal but potentially unhappy minority as concerns or side effects most discussed online may also be the most impactful when they occur in clinical practice or be the most of interest to preoperative patients who may have come across these concerns while researching their options on the internet. Patients and

surgeons may find these results important in tailoring the choice of lens for the individual patients according to their tolerance of potential side effects.

Conclusions

There is a critical need for evaluating patient-centered outcomes and detecting patients' concerns regarding emerging technology in ophthalmology where rapid surgical innovation with new technologies is transforming care. Internet health forums provide a robust platform for individuals to discuss real-time health concerns and may serve as a resource to identify patient concerns associated with emerging technologies. We demonstrate the use of natural language processing as a powerful tool to gain insight into large amounts of unstructured text data provided by the patient, in this case to understand patient perspectives towards cataract surgery options. We found that sentiment towards monofocal lenses is positive, and sentiment towards multifocal lenses overall slightly negative, though attitudes towards newer multifocal lenses may be more positive. Patients were concerned about both common and some uncommon side effects. Understanding cataract surgery from the patient perspective can be used to improve pre- and postoperative counseling to better address patient-centered concerns and to develop measures of patient-centered outcomes in the future. This study serves as an example of utilizing cutting-edge technology to understand healthcare attitudes and outcomes from the patient perspective and can be applied to many different areas of healthcare and sources of text.

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