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Public Interest in Prostatic Artery Embolization: An Analysis of Search Query Data

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Abstract

Background: Prostatic artery embolization (PAE) is an emerging treatment for benign prostatic hyperplasia (BPH). However, changes in public interest in PAE over time, especially relative to interest in alternative BPH treatments, are difficult to assess. The online tool for analysis of the popularity of top search queries (Google Trends; Alphabet Inc) provides a relative search volume (RSV) of specified keywords and insight about patterns of user searches.

Purpose: The purpose of this study is to assess changes in public interest in PAE over time and compare them with changes in public interest in alternative BPH treatments as indicated by search queries.

Material and Methods: Using Google Trends, we identified the RSV of specified keywords within search queries submitted between 2010 and 2019 in the United States. The RSVs of keywords with high search volume were identified and normalized on a scale of values from 0 to 100. Interest in PAE was assessed by comparing RSVs and trends of the keyword *PAE* as well as of other prostate-treatment-related keywords. *Prostate embolization* was a PAE-related, BPH-treatment-specific keyword with the highest average RSV. A linear regression analysis was performed to characterize annual search trends of the use of these keywords. Subsequently, the annual search trend of *prostate embolization* was compared with that of keywords related to transurethral resection of the prostate (TURP) and minimally invasive surgical treatments (MISTs).

Results: The mean annual RSV of *prostate embolization* increased by 8.6 fold between 2010 and 2019. However, during this period, the mean RSV of the keywords *transurethral resection of the prostate* and *TURP* were 3.6 and 49.3 times higher, respectively ($P < 0.0001$), than the mean annual RSV of *prostate embolization*. Moreover, the MIST-related keywords *rezum* and *urolift* showed respective mean RSVs 3.1 and 9.0 times higher ($P < 0.0001$) than the mean annual RSV of *prostate embolization*.

Conclusions: Search query data can elucidate public interest in interventional radiologic (IR) procedures. An increase in RSVs of PAE keywords over time suggests increasing public knowledge of and about the procedure. However, the RSVs of PAE keywords is far lower than the RSVs of keywords related to urologic surgeries, suggesting the need for continued efforts to educate patients and providers about the nature and the values of IR procedures.

Keywords: *prostatic artery embolization, Google Trends, relative search volume, search query*

Introduction

Transurethral resection of the prostate (TURP) is the most common procedure performed to relieve lower urinary tract symptoms (LUTS) secondary to benign prostatic hyperplasia (BPH).^{1,2} However, the morbidity associated with TURP has prompted the development of less invasive procedures.³⁻⁵ Minimally invasive surgical treatments (MISTs) such as microwave ablation, electrovaporization, hydrodissection, and prostatic urethral lift have become more common in recent years.^{4,6,7} Prostatic artery embolization (PAE) has also emerged as a minimally invasive transarterial treatment for LUTS attributed to BPH. This treatment is performed by an interventional radiology (IR) physician who employs imaging guidance to catheterize and occlude the arteries supplying the prostate with the goal to induce ischemia and reduce the prostate gland volume.² The procedure was first described as a treatment for BPH in 2000 and, following rigorous investigation, has been determined as safe and effective for the treatment of BPH.⁵ However, the changes in public interest in PAE over time and in relation to other BPH treatments is difficult to assess.

Internet searches are an important tool to obtain medical information. A survey of households in the United States of America (USA) revealed that 40% of people with internet access used the internet to obtain advice or information about health or health care, with one third of those reporting that their search affected their medical decisions.⁸ Analysis of search query data has been shown to be an indirect marker of geographic and temporal variability in medical conditions, such as kidney stone disease and influenza.⁹⁻¹¹ Utilization of this data has also been viewed as an efficient way to direct resources and marketing.¹² The aim of this study is to assess interest in PAE and make comparisons to interest in TURP and MIST using search query data.

Materials and Methods

Google Trends (Alphabet Inc) provides publicly available data sets of relative search volume (RSV), the ratio between a user-defined keyword

Key Points

- *Prostate embolization* is the most searched keyword specific to PAE; its mean annual RSV has increased 8.6 fold between 2010 and 2019.
- The TURP-related keywords have RSVs up to 49.3 times higher than the RSV of *prostate embolization*.
- The MIST-related keywords have RSVs up to 9.0 times higher than the RSV of *prostate embolization*.

Abbreviations

ANOVA: analysis of variance
 BPH: benign prostatic hyperplasia
 IP: internet protocol
 IR: interventional radiology
 LUTS: lower urinary tract symptoms
 MIST: minimally invasive surgical treatment
 PAE: prostatic artery embolization
 RSV: relative search volume
 SD: standard deviation
 SEE: standard error of the estimate
 TURP: transurethral resection of the prostate
 USA: United States of America

search volume and the total regional/global search volume for the same period. Each RSV is assigned a value from 0 to 100, in which 100 represents the highest keyword search frequency over the specified period. Google Trends does not display search terms with low search volume and repeated searches from a single internet protocol (IP) address to avoid the inclusion of multiple searches by the same user.¹³

Interest in PAE was evaluated based on the use of the following search terms: *prostate embolization*, *prostate artery embolization*, *prostatic artery embolization*, *PAE*, and *PAE prostate*. The RSVs of the specified keywords were determined within search queries performed in the USA between 2010 and 2019. *Prostate embolization* was the most common PAE-specific keyword that was subsequently used to compare trends of searches with the TURP-related and the MIST-related keywords.

Interest in PAE relative to TURP was assessed based on the use of the following search terms: *prostate embolization*, *transurethral resection of*

prostate, transurethral resection prostate, transurethral resection of the prostate, and TURP. The MIST-related keywords were searched independently to determine keywords with the highest RSVs. The MIST-related keywords *rezum, urolift, and aquablation* were found to have the highest RSVs and were subsequently used to compare their annual search trends to the RSV of *prostate embolization*.

Brown-Forsythe non-parametric analysis of variance (ANOVA) was performed because the variances were heterogeneous.¹⁴ The Games-Howell multiple comparisons test was used to compare mean annual RSVs of the search keywords.¹⁵ Linear regression analysis was performed to characterize annual search trends ($P < 0.05$ considered significant). Statistical analyses were performed by using commercial scientific 2D graphing and statistics software (Prism 8.4; GraphPad Software Inc; IBM SPSS Statistics 24).

Results

Evaluation of the PAE-related keywords revealed that the keyword *PAE* had the highest RSV (Figure 1). However, upon investigation of searches made with this keyword, it was found that these searches were typically associated with a name acronym of a defense and government services contractor. Therefore, the keyword *PAE* was excluded from the research, and the comparison was made between the mean annual RSVs of the remaining PAE-related keywords (Figure 2). *Prostate embolization* was the next most frequently searched PAE-related keyword. With an average RSV of 35.2, this keyword was used for subsequent comparisons between the PAE-related, the TURP-related, and the MIST-related keywords. The other PAE-related keywords included *prostate artery embolization, prostatic artery embolization, and PAE prostate* with average RSVs of 21.9; 19.1; and 16.5, respectively.

The mean annual RSV of *prostate embolization* increased by 8.6 fold, from 4.9 in 2010 to 42.0 in 2019. This increase was observed during each year except 2010, 2015, and 2018 (Figure 3).

There was a statistically significant linear increase in monthly RSV of this keyword over time ($Y = 6.070 \cdot X - 4.340$; $P < 0.0001$; $R^2 = 0.9340$; $SEE = 2.2484$).

The RSVs of the TURP-related keywords were consistently higher than the RSV of *prostate embolization*, with a statistically significant difference ($P < 0.0001$) (Figure 4). The two highest RSVs of the TURP-related keywords, *transurethral resection prostate* and *TURP*, were respectively 3.6 and 39.3 times larger than the RSV of *prostate embolization*.

Figure 1. Google Trends results of search queries on the use of the PAE-related keywords

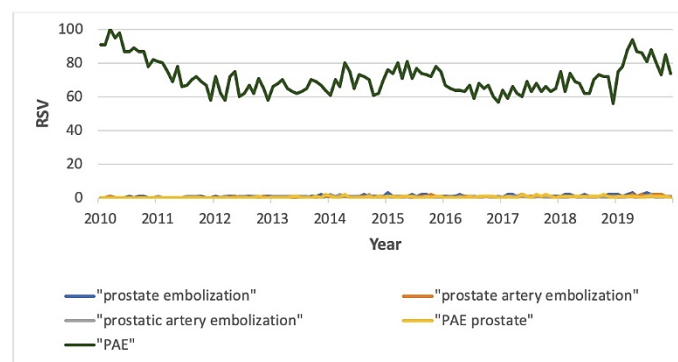
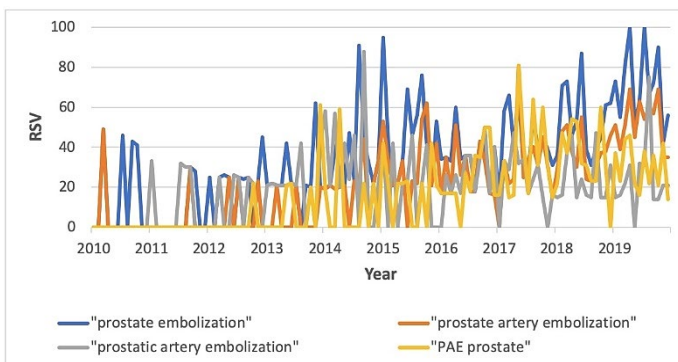


Figure 2. Google Trends results of search queries on the use of the PAE-related keywords; the keyword *PAE* is excluded



The MIST-related keywords showed low RSVs prior to 2013, similar to the RSV of *prostate embolization* (Figure 5). However, because of increases in RSVs within the last five to six years, the mean annual RSVs of *rezum* and *urolift* between 2010 and 2019 were respectively 3.1 and 9.0 times larger than the mean annual RSV of *prostate embolization*. The linear increasing trends for both *rezum* and *urolift* were not significantly different ($P = 0.954$) from 2015 to 2019. The

difference between mean RSVs of *rezum* and *urolift* during 2015-2019 was 27.268; SD = 1.943. The mean RSV of *aquablation* was 5.6 times lower relative to that of *prostate embolization*. The difference between the mean annual RSVs of *prostate embolization* and the MIST-related keywords was statistically significant ($P < 0.0001$).

Figure 3. Mean annual RSVs of the keyword *prostate embolization*

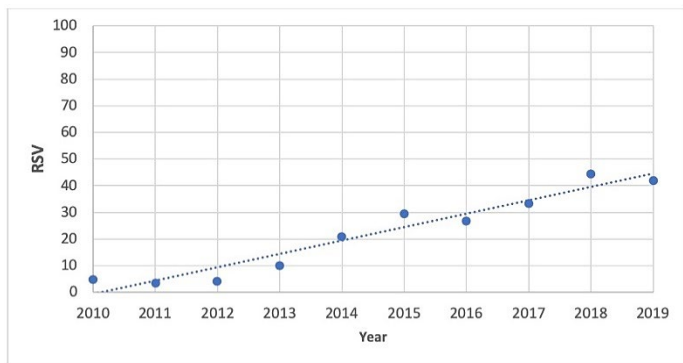


Figure 4. Google Trends results of search queries on the use of the keyword *prostate embolization* and the TURP-related keywords

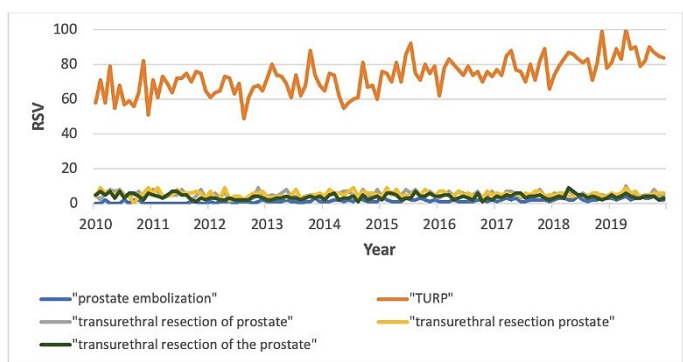
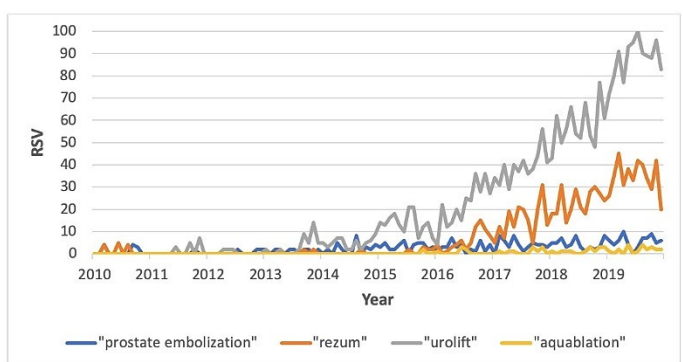


Figure 5. Google Trends results of search queries on the use of the keyword *prostate embolization* and the MIST-related keywords



Discussion

Our study showed an increase in the relative number of the PAE-related searches between 2010 and 2019, which likely reflects a growing public interest in PAE as a treatment option for BPH. The PAE-related keywords evaluated in this study, in particular *prostate embolization*, displayed an annual increase in RSVs with few contractions. Online medical resources provided for patients by health care agencies and the Society of Interventional Radiology are expected to play an important role in this trend. However, many patients as well as referring healthcare providers are still unfamiliar with minimally invasive procedures like PAE.^{16,17} The internet can be an important source for patients needing to obtain medical information and weighing on different treatment options.⁸ Therefore, providing new, interactive internet resources for patients with LUTS due to BPH can be an effective way to increase public awareness of PAE.

Despite annual increases in RSVs of the PAE-related keywords, overall mean RSV of these keywords was lower than overall mean RSV of most of the keywords related to surgical BPH treatments. The most striking difference was between mean RSVs of *prostate embolization* and *TURP*, 49.3 times higher for the latter. Higher RSVs of the TURP-related keywords were, however, expected as TURP is considered the “gold standard” surgical treatment for BPH.¹ A higher RSV of *TURP* over RSVs of the other TURP-related keywords may be attributed to *TURP* being a relatively short and unique acronym without other common associations. Consequently, using memorable names and acronyms for new or existing IR procedures may improve their marketability and visibility.¹⁶

The increase in treatments alternative to TURP has been stimulated by TURP-related morbidity, including risks of erectile dysfunction, urinary incontinence, and retrograde ejaculation.³⁻⁵ As alternative BPH treatments have become more popular, there has been a relative decrease in the number of TURPs performed.¹⁸ Annual increases in RSVs of the PAE-related and the MIST-related keywords reflect this change in patient and provider preferences. Notably, recent increases in RSVs of some of the MIST-related keywords have

exceeded the RSV of *prostate embolization*, likely reflecting higher public awareness of MIST than of PAE. Directly targeting the increasing number of patients interested in minimally invasive treatments of BPH could be an effective way to increase visibility of PAE.

The following limitations should be considered when interpreting the results of the present study. First, Google Trends provides normalized search volume and does not specify the absolute number of searches of a given keyword. Although normalized search volume allows for comparisons of keywords RSVs and the analysis of their trends over time, it does not provide the absolute number of people interested in PAE and alternative treatments. Furthermore, because Google Trends uses only a percentage of searches without disclosing the sample sizes, there is most likely a discrepancy between online search for BPH treatment and real BPH-related treatment activities, which might make this study liable to a sampling error.¹⁹ Second, the anonymous nature of normalized search volume does not make it possible to determine the intent of user searches. Information regarding related searches does provide some insights for keywords that may have multiple usages. However, with the data provided, it is uncertain whether the searches were made by patients considering these treatment options or by casual internet users. One study found online consumer information regarding PAE to be overall low-to-moderate quality with a high frequency of non-evidence-based claims.²⁰ Although we did not evaluate the quality of online searches, lower quality search results may have affected overall patients' interest and further queries. Third, misspelled keywords, even with close spelling approximations, were not included in the RSV of a given keyword. This possibly caused an underestimation of the RSVs of difficult-to-spell keywords.

The rise in RSV of the PAE-related keywords likely reflects an increased public interest in these procedures for the treatment of BPH. Although TURP is the most commonly performed procedure, the rising RSVs of alternatives to TURP reflects the growing popularity of minimally invasive treatment options. The power of the internet to disseminate information and influence medical decisions make it an effective tool to directly

inform patients of PAE and evaluate interest in PAE as a possible treatment option for BPH.

Author Contributions

Conceptualization, J.P.M.; Acquisition, analysis, interpretation of data, and writing – original draft preparation, L.R.C. and S.M.; Statistical analysis, J.W.S.; Review and editing, J.P.M. and L.R.C.; Supervision, J.P.M. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Disclosures

None to report.

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