Original Manuscript

ASRS American Society of Retina Specialists

Journal of VitreoRetinal Diseases
2025, Vol. 9(5) 584–591

DOI: 10.1177/24741264251358073
journals.sagepub.com/home/jvrd
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Temporal Trends and Regional Variations in Retinal Detachment Repair Procedures in the United States

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Abstract

Purpose: To describe whether monitoring shifts in practice patterns and reimbursements for retinal detachment (RD), a sight-threatening condition requiring prompt treatment, can improve patient outcomes and optimize healthcare resource allocation. **Methods:** This cross-sectional population-based study evaluated trends and geographic variations in RD repair procedures using US Medicare fee-for-service provider utilization and payment Part B data from 2013 to 2021. Our analysis used Current Procedural Terminology codes for pars plana vitrectomy (PPV), complex repair, scleral buckling, pneumatic retinopexy, photocoagulation, and cryotherapy. We also included an examination of changes in insurance reimbursement. **Results:** Between 2013 and 2019, we observed a significant, 7.3% increase in the total number of procedures. However, in 2020, the COVID-19 pandemic led to an 11.1% decline in procedures, with an incomplete recovery in 2021. While use of other procedures declined, PPV and complex repair were the most common across geographic regions, showing rising trends over time. The average Medicare reimbursement for RD repairs dropped by 29%, with cryotherapy facing the largest reduction. Female ophthalmologists received significantly lower average standardized Medicare reimbursements for PPV (adjusted mean difference, $81.90; 95% CI, 48-115.80; $P < .001$) and complex repair (adjusted mean difference, $218.30; 95% CI, 156-280.70; $P < .001$) and higher reimbursements for pneumatic retinopexy procedures (adjusted mean difference, $13.80; 95% CI, 3.50-24.20; $P = .009$) after adjusting for confounders. **Conclusions:** PPV has become the predominant procedure among Medicare beneficiaries across geographic regions. Decreasing reimbursements, the COVID-19 pandemic, and patient- and surgeon-related factors influence these trends in RD repair. Significant reimbursement disparities between male and female ophthalmologists for pneumatic retinopexy, PPV, and complex repair procedures have also been identified.

Keywords:
retinal detachment repair, pars plana vitrectomy, practice pattern, Medicare

Introduction

Retinal detachment (RD) is a vision-threatening condition with a relative incidence of 1 in 10 000 individuals.[1] Over time, various surgical and nonsurgical treatment options have been developed for the repair of RDs. Scleral buckle surgery was the treatment of choice for most cases prior to the 1980s.[2] However, recent studies indicate a substantial shift in practice from scleral buckling toward primary pars plana vitrectomy (PPV).[3] The development of microincisional instruments and improved visualization systems has contributed to the growing popularity of PPV.[4] Scleral buckling remains a viable option, particularly for younger patients and phakic eyes.[4] Another treatment option, pneumatic retinopexy, has shown promising results in appropriate candidates and offers comparable— and sometimes superior— visual outcomes compared with PPV.[5] Physicians also use laser photocoagulation or cryotherapy, often in conjunction with other procedures, to manage RDs effectively.[6]

The optimal approach to RD repair remains a subject of ongoing debate, influenced by clinical considerations as well as a range of external factors. Patient preference plays a role, and variations in geographic region and access to surgical facilities further complicate the decision-making process.[7] Increasing reimbursements for office-based care is an emerging trend that has contributed to the relative devaluation of surgical procedures and may influence clinical decisions.[8] The discrepancy between the time invested in surgery and reimbursements can disincentivize surgeons and practices from performing more

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time-consuming surgeries (eg, scleral buckling or combined scleral buckling and PPV) in favor of shorter surgeries or in-office procedures.[8] The COVID-19 pandemic further complicated the clinical decision-making, as healthcare priorities shifted and elective surgeries were deferred during the early months of 2020 to preserve and redirect healthcare resources.[9] These necessary adaptations introduced new challenges and inconsistencies in patient care throughout the pandemic.

In this study, we used the US Medicare database to investigate trends in RD repair practices over time and across regions. Our analysis, spanning from 2013 to 2021, also highlights the economic aspects of RD management among Medicare beneficiaries. Monitoring shifts in practice patterns and reimbursements may help improve patient outcomes, optimize resource allocation, and inform the development of future educational programs.

Methods

We analyzed publicly available Medicare fee-for-service provider utilization and payment data compiled by the Centers for Medicare and Medicaid Services from 2013 to 2021.[10] We included only Medicare fee-for-service Part B datasets, which are subject to certain privacy protections. Specifically, Medicare carriers withhold information on services provided to fewer than 11 beneficiaries at the provider and geographic levels.[11] In other words, any services rendered by a healthcare provider to fewer than 11 beneficiaries are not included in the publicly available datasets.

Data were extracted using Current Procedural Terminology (CPT) codes, including 67101 (cryotherapy), 67105 (photocoagulation), 67107 (scleral buckling), 67110 (pneumatic retinopexy), 67108 (pars plana vitrectomy with or without other techniques), and 67113 (complex vitrectomy with membrane peeling). We collected provider-level data, including sex, National Provider Identifier number, practice location, number of procedures performed, and Medicare payment amounts aggregated by year. To enhance analytical robustness and ensure accurate comparisons over time, we adjusted for fluctuations in Medicare enrollment by dividing the number of procedures by the number of Medicare Part B beneficiaries for each year. For reimbursement analysis, we used the average standardized facility-based payment amount, which represents the average Medicare payments per procedure after geographical standardization. Reimbursement amounts were adjusted for inflation using the US Bureau of Labor Statistics Consumer Price Index.[12] To analyze geographic variations, we categorized the practice locations into 4 regions based on US Census Bureau definitions: Northeast, South, Midwest, and West.[13] For provider-level analysis, we cross-referenced our dataset with the national downloadable file, using National Provider Identifier numbers to obtain information on each physician's graduation year. These data were available for 90.4% of ophthalmologists included in the study.

Descriptive statistics, including independent samples *t*-tests, Mann-Whitney *U* tests, and Spearman rank correlation coefficients, were used to summarize total numbers and temporal trends. Categorical variable comparisons were made using Pearson χ^2 tests. A P value $< .05$ was considered statistically significant. To assess provider-level differences in Medicare reimbursements, we used a multivariable linear regression model. This model allowed us to compare average standardized payment amounts while controlling for factors such as reimbursement year, years of professional experience, total procedure volume, and place of service (facility-based and non–facility-based). Statistical analysis and graphs were prepared using SPSS Statistics software (version 27, IBM) and Python (Python Software Foundation).

Results

Procedures and Trends Over Time

Between 2013 and 2021, a total of 467 220 repair procedures were performed, representing a 7.3% increase from 50 454 procedures in 2013 to 54 152 procedures in 2019 (Table 1). However, during the onset of the COVID-19 pandemic in 2020, the number of procedures declined by 11.1%. Although there was a modest 1.6% rebound in 2021, procedure volumes did not fully return to prepandemic levels. This pattern persisted even after adjusting for changes in the number of Medicare beneficiaries. The procedure rate rose from 15.2 per 10 000 beneficiaries in 2013 to 16.37 in 2019, followed by a 8.8% decline to 14.93 in 2020. In 2021, the rates increased again by 6.2% to 15.86 per 10 000 beneficiaries.

The overall distribution of procedure types remained relatively stable during the study period. PPV was the most commonly performed procedure, accounting for 47% of all procedures, followed by complex repair (35.6%), photocoagulation (9.4%), pneumatic retinopexy (5%), scleral buckling (2.1%), and cryotherapy (0.9%). Between 2013 and 2021, the proportional use of PPV and complex repair increased by 22.1% and 1.7%, respectively. In contrast, the use of other procedures declined, ranging from a 23% decrease for pneumatic retinopexy to a 56.8% decrease in cryotherapy (Figure 1A). When evaluating average annual trends from 2013 to 2019, we found that the start of the COVID-19 pandemic in 2020 was associated with additional year-over-year declines in the number of procedures: scleral buckling (–19%), photocoagulation (−18.9%), cryotherapy (−14.4%), complex repair (−13.2%), and PPV (−12%). Pneumatic retinopexy was the least affected, with only a 6.6% reduction. In 2021, procedure use rebounded across all categories except for complex repair, which demonstrated an additional 1.8% decline compared with 2020. Despite the recovery, most procedures did not return to their prepandemic levels, with the exception of cryotherapy, which surpassed its expected numbers, and pneumatic retinopexy, which nearly returned to its previous trend, with only a minimal decline of 0.05%.

Reimbursements

The average Medicare reimbursements for RD repair procedures decreased over time (Supplemental Table 1). After

Table 1. Retinal Detachment Repair Procedures Provided to US Medicare Beneficiaries From 2013 to 2021.

Year	Procedure, n (% per year)						Total, n	Total Rate[a], %
	Cryotherapy	Photocoagulation	Scleral Buckling	PPV	Pneumatic Retinopexy	Complex Repair		
2013	729 (1.4)	6371 (12.6)	1604 (3.1)	21 349 (42.3)	2998 (5.9)	17 403 (34.5)	50 454	15.22
2014	641 (1.2)	6129 (12.2)	1437 (2.8)	21 714 (43.2)	2818 (5.6)	17 457 (34.7)	50 196	15.12
2015	648 (1.2)	6071 (11.6)	1301 (2.5)	22 720 (43.5)	2878 (5.5)	18 626 (35.6)	52 244	15.69
2016	616 (1.1)	6435 (11.7)	1100 (2)	24 780 (45.1)	2709 (4.9)	19 277 (35.1)	54 917	16.28
2017	453 (0.8)	4729 (8.8)	1012 (1.9)	25 608 (47.6)	2697 (5)	19 302 (35.9)	53 801	16.03
2018	402 (0.7)	3978 (7.3)	1001 (1.8)	26 591 (48.9)	2574 (4.7)	19 812 (36.4)	54 358	16.29
2019	365 (0.6)	3987 (7.3)	927 (1.7)	26 782 (49.4)	2406 (4.4)	19 685 (36.3)	54 152	16.37
2020	274 (0.5)	2962 (6.1)	671 (1.4)	24 593 (51)	2160 (4.5)	17 497 (36.3)	48 157	14.93
2021	305 (0.6)	3246 (6.6)	695 (1.4)	25 282 (51.6)	2237 (4.6)	17 176 (35.1)	48 941	15.86

Abbreviation: PPV, pars plana vitrectomy.
[a]Rate per 10 000 Medicare Part B beneficiaries.

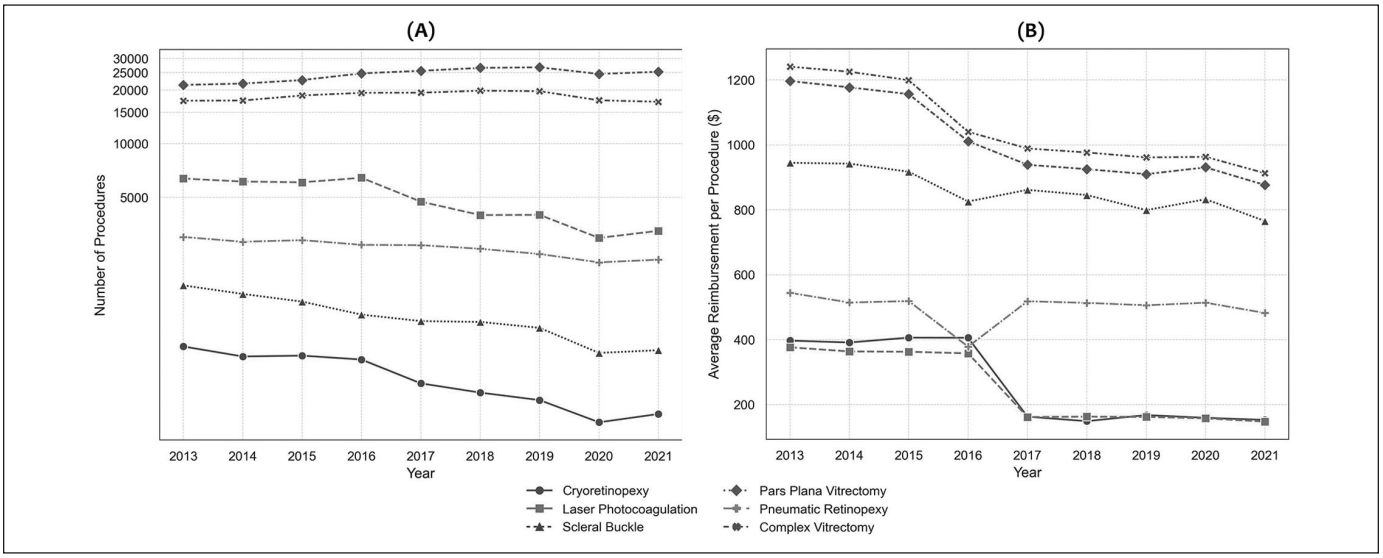

Figure 1. Trends of retinal detachment (RD) repair procedures and Medicare reimbursements from 2013 to 2021. (A) Number of RD procedures provided to Medicare beneficiaries from 2013 to 2021. (B) Average facility-based payment amount from Medicare for each procedure from 2013 to 2021.

adjusting for inflation, the mean remuneration declined from $4,700.50 in 2013 to $3,337.10 in 2021, indicating an overall reduction of 29%. The highest decline was noted for cryotherapy (61.5%), followed by photocoagulation (60.8%), PPV (26.7%), complex repair (26.4%), scleral buckling (19%), and pneumatic retinopexy (11.4%) (Figure 1B). Significant negative correlations were found between year and inflation-adjusted reimbursements for cryotherapy ($\rho = -0.73$; $P = .02$), photocoagulation ($\rho = -.95$; $P < .001$), scleral buckling ($\rho = -0.86$ $P = .002$), PPV ($\rho = -0.95$; $P < .001$), and complex repair ($\rho = -0.98$; $P < .001$), indicating suggesting consistent downward trends. However, no statistically significant correlation was found between time and reimbursement for pneumatic retinopexy ($\rho = -0.63$; $P = .06$), suggesting the absence of a clear trend.

Regional Variations

The number and regional distribution of procedures are summarized in Table 2. The South accounted for the highest volume of procedures (185 163, 40.5%), followed by the West (99 060, 21.6%), Midwest (97 597, 21.3%), and Northeast (75 474, 16.5%). When adjusted for the number of Medicare beneficiaries, the West had the highest rate of procedures at 153.9 per 10,000 beneficiaries over the 9-year period, followed by the South (142.8), Midwest (131.3), and Northeast (126.4). Across all regions, PPV and complex repair were the most frequently performed procedures, while cryotherapy and scleral buckling were the least common. Significant regional differences in procedure utilization were observed. The Midwest showed a higher use of cryotherapy ($P = .006$

Table 2. Retinal Detachment Repair Service Provided to Medicare Beneficiaries From 2013 to 2021 by US Census Bureau Region.

	Procedure, n (%)							
Region	Cryotherapy	Photocoagulation	Scleral Buckling	PPV	Pneumatic Retinopexy	Complex Repair	Total, n	Total Rate[a]
Midwest	837 (0.8)	7805 (8.0)	2410 (2.4)	48 505 (49.7)	3955 (4.0)	34 085 (34.9)	97 597	131.3
Northeast	377 (0.5)	10 701 (14.2)	1633 (2.1)	33 163 (43.9)	4631 (6.1)	24 969 (33.0)	75 474	126.4
South	947 (0.5)	14 809 (8.0)	2799 (1.5)	88 003 (47.5)	8498 (4.6)	70 107 (37.8)	185 163	142.8
West	739 (0.7)	8816 (8.9)	1563 (1.6)	48 294 (48.7)	4398 (4.4)	35 250 (35.6)	99 060	153.9

[a]Rate per 10 000 Medicare Part B beneficiaries.
Abbreviation: PPV, pars plana vitrectomy.

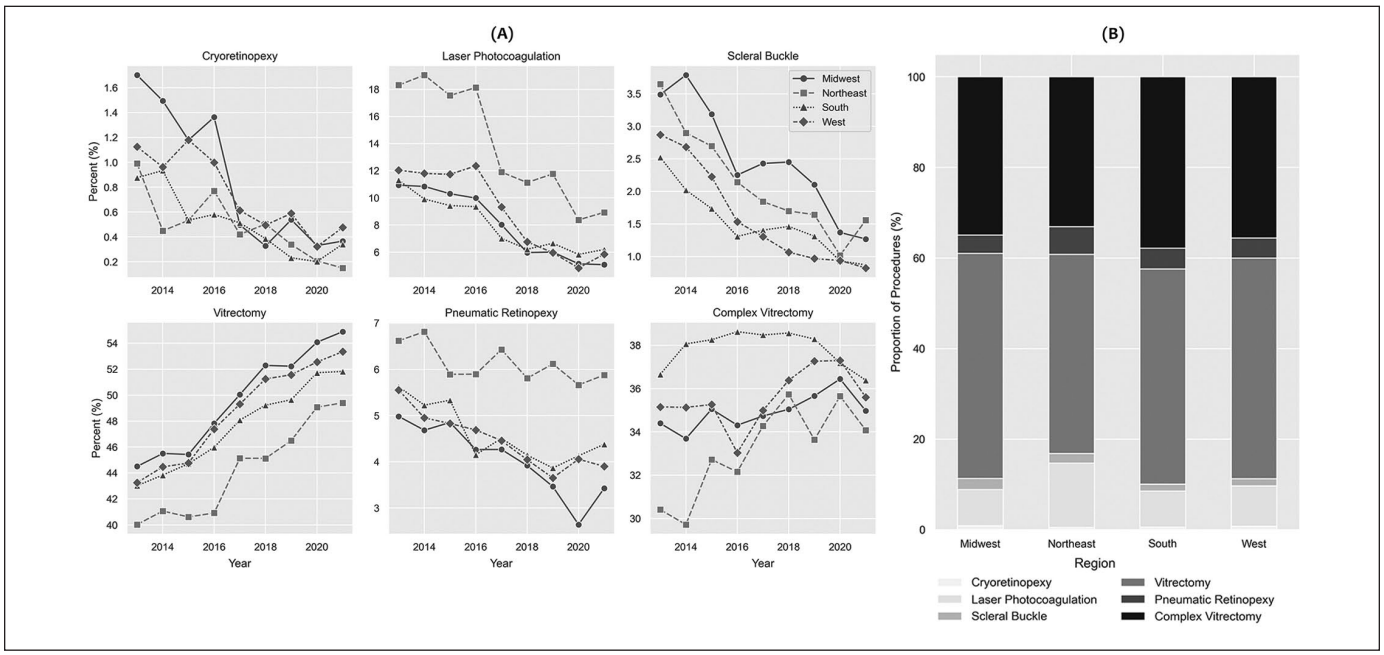

Figure 2. Regional variation of retinal detachment (RD) procedures. (A) Annual proportion of RD procedures in US Census Bureau regions. (B) Relative use of RD procedures in the US Census Bureau regions between 2013 and 2021.

vs. West; $P < .001$ vs. other regions). In contrast, the Northeast had higher utilization of laser photocoagulation ($P < .001$) and pneumatic retinopexy ($P < .001$). Complex repair was performed more frequently in the South compared with other regions ($P < .001$) (Figure 2).

Surgeon Preference

Physician-level data were analyzed for 1685 ophthalmologists who performed at least 11 RD repair procedures annually for Medicare beneficiaries. Of these, 215 (12.7%) were women. Between 2013 and 2021, female specialists accounted for only 8.3% of all procedures performed (Table 3). Overall, male and female ophthalmologists demonstrated similar procedural preferences; however, the relative proportions of procedures differed significantly by sex ($P < .001$). Female ophthalmologists performed a higher percentage of PPV (62.1% vs. 55.9% ; $P < .001$) and a lower proportion of photocoagulation ($P < .001$), pneumatic retinopexy ($P < .001$), and complex repair ($P = .004$). After the model was adjusted for years of professional experience, number of procedures performed, reimbursement year, and location of services, female ophthalmologists received lower average standardized Medicare reimbursements for both PPV (adjusted mean difference, \$81.9; 95% CI, 48-115.8; $P < .001$) and complex repair (adjusted mean difference, \$218.3; 95% CI, 156-280.7; $P < .001$). In contrast, female physicians received higher average payments for pneumatic retinopexy procedures compared with their male counterparts (adjusted mean difference, \$13.8; 95% CI, 3.5-24.2; $P = .009$).

Conclusions

Our study provided insights into the evolving landscape of all-cause RD repair procedures among Medicare beneficiaries. We observed an overall increase in the total number of procedures between 2013 and 2020, followed by a notable decline in 2020

Table 3. Summary of Procedures Provided to Medicare Beneficiaries by Male and Female Ophthalmologists From 2013 to 2021.[a,b]

	Number of Services (% per year)								
Procedure	2013	2014	2015	2016	2017	2018	2019	2020	2021
Female physicians									
Cryotherapy	NA	NA	NA	NA	NA	14 (0.8)	NA	NA	11 (0.8)
Photocoagulation	126 (11.4)	124 (12.9)	71 (7.7)	87 (6.7)	98 (5.8)	NA	33 (2)	14 (1.05)	31 (2.2)
Scleral buckling	17 (1.5)	15 (1.6)	NA	NA	NA	NA	NA	NA	NA
Pars plana vitrectomy	571 (51.5)	471 (49.2)	549 (59.4)	646 (50.1)	1057 (63.1)	1181 (68.8)	1144 (69.7)	885 (66.6)	968 (70)
Pneumatic retinopexy	NA	NA	15 (1.6)	NA	11 (0.6)	15 (0.9)	NA	NA	28 (2)
Complex repair	394 (35.5)	347 (36.2)	289 (31.3)	555 (43.1)	509 (30.4)	506 (29.5)	464 (28.3)	430 (32.3)	345 (24.9)
Male physicians									
Cryotherapy	132 (0.8)	53 (0.3)	72 (0.5)	48 (0.2)	11 (0.07)	NA	12 (0.08)	NA	20 (0.1)
Photocoagulation	2188 (13.9)	2003 (13)	1977 (12.4)	2034 (12.2)	918 (5.9)	738 (4.8)	600 (4.1)	379 (3.2)	440 (3.7)
Scleral buckling	41 (0.2)	56 (0.4)	68 (0.4)	13 (0.08)	89 (0.5)	42 (0.3)	24 (0.1)	12 (0.1)	22 (0.1)
Pars plana vitrectomy	7749 (49.2)	7576 (49.3)	8006 (50.4)	8930 (53.4)	9147 (59.3)	9173 (60)	8936 (60.8)	7165 (60.6)	7580 (64.2)
Pneumatic retinopexy	205 (1.3)	219 (1.4)	169 (1.1)	232 (1.4)	207 (1.3)	220 (1.4)	121 (0.8)	181 (1.5)	171 (1.4)
Complex repair	5420 (34.4)	5451 (35.5)	5601 (35.2)	5465 (32.7)	5057 (32.8)	5128 (33.5)	5015 (34.1)	4086 (34.5)	3564 (30.2)

[a]Number of procedures were not reported if physicians performed fewer than 11 procedures per year.
[b]"NA" indicates the absence of available data for a particular procedure in a given year.

at the onset of the COVID-19 pandemic. While procedure volumes increased in 2021, they did not return to prepandemic levels. This fluctuation reflects several contributing factors, including a 5.7% reduction in the number of Medicare beneficiaries between 2019 and 2021, as well as pandemic-related disruptions such as temporary clinic closures and a reduction in elective anterior segment surgeries.[14,15] An observed increase in in-office procedures, such as cryotherapy, during the pandemic-may have been driven by limited access to operating rooms.

We found an increasing preference for PPV over scleral buckling and pneumatic retinopexy, consistent with previously reported trends among Medicare,[16,17] Medicare Advantage, and commercially insured populations.[3,18] While scleral buckling has traditionally been used in RD repair, its popularity has declined since the advent of small-gauge vitrectomy systems. Nevertheless, scleral buckling remains highly effective, particularly in younger, phakic patients.[19] Studies comparing scleral buckling and PPV in phakic eyes have demonstrated comparable or even superior anatomic and visual outcomes with scleral buckling,[20–23] although it is less suitable for extensive or posterior retinal breaks. Conversely, PPV is more effective in pseudophakic eyes and offers improved outcomes when combined with scleral buckling.[21]

Among Medicare beneficiaries — who are generally older and more likely to be pseudophakic or have higher incidence of posterior vitreous detachment — PPV remains the most commonly selected procedure.[24,25] However, a demographic shift toward younger beneficiaries (aged 65 to 74 years) within Medicare Part B was noted during the study period,[26] but the increasing preference for PPV persisted. This sustained trend likely reflects not only clinical factors,[7,27,28] but also surgeon-related factors, such as age, training background, years of experience, and comfort level with a particular procedure.[27,29,30] Younger physicians, in particular, are more likely to favor PPV over scleral buckling.[27,29,30] The adoption of more advanced PPV tools, relatively shorter surgical time, and the prevailing reimbursements can also impact the decision-making process.[3,27]

Pneumatic retinopexy, often used for RD resulting from superior retinal breaks, offers comparable or superior visual outcomes compared to PPV[5] and comparable anatomic success compared to scleral buckling.[31] It is cost-effective, requires minimal anesthesia, and can be performed in outpatient settings with faster visual recovery. However, successful outcomes heavily depend on patient selection, physician skills, and postoperative positioning. The nuanced requirements of pneumatic retinopexy might deter its preference, especially given the variable technical training during fellowship.[30] In our study, pneumatic retinopexy was more frequently used than scleral buckling and was favored particularly in the Northeast, suggesting that geographic, reimbursement, and practice style differences may influence the choice of procedures.[27]

Between 2013 and 2021, there was a consistent downward trend in Medicare inflation-adjusted reimbursements for all RD repair procedures. Cryotherapy and laser photocoagulation experienced the largest reductions, followed by PPV and scleral buckling. This aligns with prior research highlighting a 30% decline in PPV reimbursements.[32] Ideally, reimbursement levels should reflect the true costs incurred by providers. Persistent misalignment could skew practice patterns and compromise the quality of care.[32] It has previously been shown that the reimbursements for PPV and, to a greater degree, for complex repairs may not fully cover the associated costs.[33] Our results indicated a consistent downward trend in reimbursements, highlighting the importance of considering the potential impact on practice patterns and patient care.

Medicare's relative value unit framework incorporates physician work, practice-related expenses, and malpractice risk. In particular, physician work relative value units consider the level of expertise required as well as the time allocated and intensity of the given procedure.[34] However despite its higher complexity and time demands, scleral buckling carries a lower relative value unit, which may disincentivize its use in a fee-for-service system.[34] In 2016, Medicare revised the relative value unit

system to incorporate quality metrics, practice improvements, and the use of electronic health records in physician payments.[35] Our study found that these changes further affected reimbursements, resulting in a sharper decline for PPV reimbursement and a more modest drop for scleral buckling. Additionally, cryotherapy and laser photocoagulation were reclassified as minor procedures, reducing their global period from 90 to 10 days and thereby decreasing their relative value unit and reimbursement rates.[35]

Our study also identified substantial gender-based disparities in Medicare reimbursements. Female ophthalmologists received significantly lower payments for PPV and complex repair procedures, despite adjustments for physician experience, site of service, case volume, and reimbursement year. Interestingly, women received slightly higher payments for pneumatic retinopexy, although this difference was less pronounced. We also used average Medicare standardized payment amounts in our analysis, which adjust for geographic variations in payment rates for individual services. These findings are consistent with earlier research demonstrating that female ophthalmologists generally received lower annual and per-service reimbursements, particularly for vitreoretinal surgeries.[36–39] Similar trends have been observed in other surgical specialties, including pelvic surgeons, urologists, and neurosurgeons.[40–42]

Despite Medicare's gender-neutral reimbursement structure, these differences persist. One possible explanation lies in Medicare's data reporting threshold—services performed fewer than 11 times are excluded—which may lead to underreporting. Other contributing factors may include differences in coding practices, total number of patients seen and average number of services billed per patient.[39] Prior research has identified significant gender differences in in the average number of relative value units and CPT codes billed per case.[43] Although our database does not capture coding differences, previous research suggests that female physicians may bill fewer high-complexity codes or lower number of procedures per encounter.[44,45] Although our dataset did not capture coding granularity, educational efforts around medical coding and billing could be an effective strategy to mitigate disparities in reimbursement. Additionally, we were unable to account for practice-related factors, such as physician density, geographic variations in government or health system policies, subspecialties, academic rank, or leadership roles, which may also contribute to the observed payment gaps.[37] Further research is needed to understand the root causes of these payment disparities.

Our study has several limitations. The Medicare database excludes providers and services with fewer than 11 claims, limiting completeness of regional and provider-level analyses, procedures lacking detailed provider information or geographic identifiers were excluded from gender and regional subanalyses, respectively. In addition, the database does not differentiate between primary and recurrent RD repair, nor does it allow identification of RD etiology, or combined procedures such as PPV with scleral buckling. These factors may affect reimbursements and the patterns related to these procedures. Moreover, as this study relies exclusively on Medicare data, the findings may not be fully generalizable to populations with other types of insurances coverage. Lastly, as our analyses extend only through 2021, the ongoing impact of the COVID-19 pandemic remains incompletely explored.

Despite these limitations, Medicare beneficiaries present a key population for understanding national RD repair trends. The evolving landscape, encompassing decreasing reimbursements and patient and surgeon-related factors, significantly contributes to shaping trends in RD repair. Given the frequent, vision-saving nature of these procedures, it is crucial to address detrimental incentives and implement emergency management plans to uphold the highest standards of patient care. The factors highlighted in this study have the potential to influence the training and experience of future generations of specialists. Further studies are needed to better understand how these factors influence patient care and outcomes.

Ethical Approval

This study adhered to the tenets of the Declaration of Helsinki. Because a publicly available database was used, ethical approval for this study was waived by the Institutional Review Board/Ethics Committee of the University of California, Davis.

Statement of Informed Consent

Informed consent was not required for this study because no human subjects were included.

Declaration of Conflicting Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of the article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

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Supplemental Material

Supplemental material is available online with this article.

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