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Hand

Utilization of Interphalangeal Joint Arthroplasty and Arthrodesis in the United States From 2010 to 2019

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Background: Interphalangeal joint (IPJ) arthrodesis and arthroplasty are mainstay treatments for IPJ arthritis with conflicting evidence about the most efficacious choice. Our study describes case volume and incidence over the last decade (2010–2019).

Methods: The IBM MarketScan database was queried using Current Procedural Terminology codes for IPJ arthrodesis and arthroplasty from January 2010 to December 2019. Volume and incidence were estimated annually and according to sex, age, and US geographical region for 2010 and 2019.

Results: Annual volume and incidence of IPJ arthrodesis increased slightly from 2010 to 2019, though with overlapping confidence intervals for incidence. Arthrodesis tended to be higher in women versus men, especially with increasing age. When considering age, the most substantial increase in rates over increasing age was moving from the 40s to 50s age brackets. Across US regions, arthrodesis was higher in the northeast and midwest in 2010, though other rates rose and regions were similar by 2019. For IPJ arthroplasty, there was a 25%–30% decrease in case volume and incidence over the decade. Incidence was generally higher among women, with a similar jump in incidence from 40s to 50s among women, whereas men showed a more gradual rate increase with age. Regionally, arthroplasty was highest in the northeast and midwest in 2010, though it was similar across regions in 2019.

Conclusions: Although IPJ arthrodesis levels have stayed relatively stable, IPJ arthroplasty showed a general decline over the decade. Incidence of both were higher among women, and despite initial regional differences, rates became more similar by 2019.
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INTRODUCTION

Arthritis of the proximal and distal interphalangeal joints (IPJs) stems from chronic degenerative changes, inflammation, and traumatic injuries.[1] As the affected joint deteriorates, it becomes painful and functionally impaired, and operative treatment may be warranted. Arthrodesis, that is, joint fusion, has historically been the standard of care, reliably reducing pain and creating a stable joint—albeit at the expense of joint motion.[1–3] The introduction of IPJ arthroplasty followed,[4,5] replacing the joint with a prosthetic implant, and offering motion-preserving surgery that also relieved pain.[2,6,7] However, arthroplasty comes with the added risk of prosthetic infection, instability, or arthrofibrosis, with eventual loss of joint mobility.[8–20]

Despite the interest in arthroplasty,[4,7,16,21–28] in the first decade of the 21st century, multiple studies reported high complication rates.[11,12,14,16,22,29–31] However, more recent studies have shown potentially improved outcomes with innovations in implants and techniques.[13,19,20,32–39] Furthermore, medical management of underlying conditions, particularly rheumatoid arthritis, has continued to show advancements.[40] The objective of this study was to determine the case volume and incidence of IPJ arthrodesis and arthroplasty in the United States across the prior decade, between 2010 and 2019. Additionally, this study aimed to delineate incidence trends across sex, age subgroups (≤40, 40–49, 50–59, and ≥60 years), and among the 4 geographical regions of the United States.

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METHODS

Data Source

Institutional review board approval was not required because this study is a retrospective review of de-identified data in the IBM Watson Health MarketScan Commercial Claims and Encounters and Medicare Supplemental and Coordination of Benefit databases. IBM MarketScan is a collection of medical and drug insurance claims, containing data of millions of privately and publicly insured de-identified patients in the United States. The database utilizes synthetic identifiers to help safeguard patient privacy, and was designed to align with the requirements of the Health Insurance Portability and Accountability Act of 1996. The service-level, insurance claims nature of the database provides an advantage by capturing numerous aspects of US healthcare. Despite the advantages, the level of detail is limited by the way in which data is tracked and recorded (such as by Current Procedural Terminology [CPT] codes). Relevant for small joint arthroplasty, current CPT codes do not differentiate between proximal and distal IPJs. Therefore, all values of arthroplasty and arthrodesis volumes and incidences include both proximal and distal IPJs. The data should be interpreted with this important limitation in mind.

Sample Selection

Using CPT codes for IPJ arthrodesis (26860, 26861, 26862, 26863) and arthroplasty (26535, 25636), the database was queried from January 2010 to December 2019 with the goal of capturing all cases within the specified timeframe. This timeframe was selected due to limits of available data. At the time of analysis, 2019 was the most recent year made available by IBM Watson Health. Furthermore, data on population estimates were drawn from the US Census Bureau, specifically the American Community Survey for Age and Sex. The earliest available year for US Census data was 2010. Therefore, the timeframe of 2010–2019 was selected. Baseline patient demographic information (age, sex, region) was collected from the commercial claims and Medicare supplemental tables generated by the query's results.

Statistical Analysis

IBM MarketScan provides discharge weights that are constructed from the US Census Bureau Public Use Microdata Sample of the American Community Survey. These weights statistically adjust the sample data by accounting for differences between the population that comprises the sample and the actual population. The weights account for bias that results from discrepancies in the sample data. Individual weights are assigned to each sample data record based on its representation of the actual population. The higher the weight, the more representative that record is assumed to be, therefore contributing more to the overall estimate. The accumulation of each weighted record creates an overall weighted estimate of the population, allowing generalizations that are more proportionate to the US population. The weights are provided from the database and paired with the sample records using the Complex Samples function in IBM SPSS Statistics software. The Complex Samples function combines the raw values from IBM Marketscan and the discharge weights to create national estimates with 95% confidence intervals.

Annual procedural volume was defined as the total number of procedures in the given year. Population estimates from the US Census were used to calculate annual incidences each year. Annual incidence, represented as per 1,000,000, was defined as the quotient of procedural volume and the respective total population in the given year. Annual volume and incidence were determined every year from 2010 to 2019, and percentage change between years was calculated. Moreover, for 2010 and 2019, volume, incidence, and percentage change were estimated within sex and age subgroups, as well as for the 4 geographical regions of the United States (northeast, midwest, south, and west). We deemed significance as the absence of overlapping 95% confidence intervals between years, believing that nonoverlapping intervals represent 95% confidence interval that value X is different than Y. Additionally, trends of annual procedural volumes from 2010 to 2019 were presented graphically.

Takeaways

Question: What are the case volumes and incidence trends for interphalangeal joint (IPJ) arthroplasty and arthrodesis from 2010 to 2019?

Findings: IPJ arthrodesis stayed stable, whereas IPJ arthroplasty showed a general decline over the decade. Incidence of both were higher among women. Although there were initial regional differences, rates became more similar by 2019.

Meaning: The latest procedure trends can help us better understand standards of practice across the country, fuel research on factors that influence surgical choice, and help anticipate future trends in surgical management of small joints.

RESULTS

Arthrodesis

Case Volume and Incidence

In total, 68,724 IPJ arthrodesis procedures occurred in the database from 2010 to 2019. Volumes of IPJ arthrodesis remained relatively stable from year to year, with no significant percentage change (ie, nonoverlapping confidence intervals) between any 2 consecutive years. However, during the whole study period, there was a 24.1% increase in IPJ arthrodesis volume, with nonoverlapping confidence intervals between 2010 and 2019 (Fig. 1; Table 1). Despite this, the overall 10-year increase in incidence of IPJ arthrodesis was not significant with similar mild fluctuations from year to year. In other words, although IPJ arthrodesis volume rose, particularly in more recent years, there was no notable change in incidence, which accounts for population size, over the full study period (2010–2019).

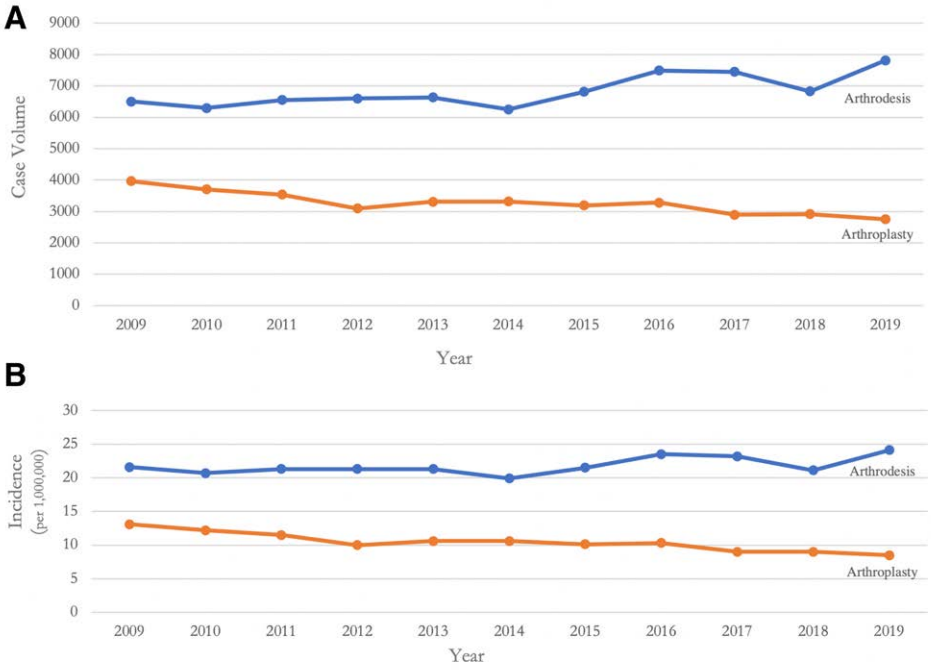

Fig. 1. IPJ arthrodesis and arthroplasty: annual volume (A) and incidence (B).

Table 1. Annual Case Volumes and Incidence of Interphalangeal Joint Arthrodesis and Arthroplasty

Year	IPJ Arthrodesis (Volume)	% Change	IPJ Arthrodesis (Incidence per 1,000,000)	% Change	IPJ Arthroplasty (Volume)	% Change	IPJ Arthroplasty (Incidence per 1,000,000)	% Change
2010	6297 (5961–6634)	—	20.7 (19.61–21.82)	—	3703 (3392–4013)	—	12.2 (11.16–13.20)	—
2011	6547 (6198–6896)	4.0	21.4 (20.21–22.50)	2.9	3537 (3271–3804)	–4.5	11.5 (10.67–12.41)	–5.7
2012	6600 (6234–6967)	0.8	21.4 (20.16–22.54)	0	3097 (2849–3344)	–12.5	10.0 (9.22–10.82)	–13.0
2013	6634 (6278–6989)	0.5	21.3 (20.15–22.43)	0	3308 (3038–3578)	6.8	10.6 (9.75–11.49)	6
2014	6251 (5881–6622)	–5.8	19.9 (18.72–21.08)	-6.6	3316 (3021–3610)	0.2	10.6 (9.62–11.49)	0
2015	6813 (6042–7583)	9.0	21.5 (19.09–23.96)	8.0	3197 (2718–3676)	–3.6	10.1 (8.59–11.61)	–4.7
2016	7491 (7026–7955)	10.0	23.5 (22.06–24.97)	9.3	3282 (2964–3600)	2.7	10.3 (9.30–11.30)	2.0
2017	7450 (6924–7977)	–0.5	23.2 (21.57–24.85)	-1.3	2898 (2555–3242)	–11.7	9.0 (7.96–10.10)	–12.6
2018	6826 (6291–7360)	–8.4	21.1 (19.48–22.79)	-9.0	2915 (2537–3293)	0.6	9.0 (7.86–10.20)	0
2019	7815 (6937–8693)	14.5	24.1 (21.36–26.77)	14.2	2752 (2202–3302)	–5.6	8.5 (6.78–10.17)	–7.8
Overall		24.1*		16.4		–25.7*		–30.3*

Incidence represented as estimates with 95% confidence interval.
Percentage change between the year displayed and the prior year is shown, along with overall percentage change from 2010 to 2019.
*Nonoverlapping confidence intervals between 2010 and 2019.

Sex

Incidence of IPJ arthrodesis was determined for men and women separately in 2010 and 2019 (Table 2). IPJ arthrodesis was performed more than 2 times as frequently in women, and this was consistent across time. Both men and women showed similar increasing trends in incidence of arthrodesis over time, at around a 16% increase, albeit with overlapping confidence intervals across the study years.

Sex and Age

To explore findings in more depth, incidence was further stratified by sex and age (<40, 40–49, 50–59, 60+ years; Table 3). This subgrouping revealed an annual incidence of IPJ arthrodesis that was highest among women in the 60+ and 50–59 age categories in both 2010 and 2019, compared with all other groups. No one age group showed a significant change across time from 2010 to 2019. As expected, incidence rose with increasing age, though the most notable jump was from the 40s to 50s age range for both men and women.

Region

Incidence was stratified by US regions for 2010 and 2019 (Fig. 2; Table 4). In 2010, IPJ arthrodesis incidence was higher in the northeast and midwest, compared with the south and west. Incidence rose in the south and west during the study period, increasing 48.6% and 62.3%,

Table 2. Incidence of Interphalangeal Joint Arthrodesis and Arthroplasty by Sex

	IPJ Arthrodesis			IPJ Arthroplasty		
	2010 Incidence (per 1,000,000)	2019 Incidence (per 1,000,000)	% Change	2010 Incidence (per 1,000,000)	2019 Incidence (per 1,000,000)	% Change
Male	12.5 (11.27–13.70)	14.5 (11.44–17.50)	16.0	8.2 (6.86–9.52)	5.5 (3.27–7.75)	−32.9
Female	28.7 (26.80–30.56)	33.4 (28.91–37.85)	16.4	16.0 (14.5–17.62)	11.4 (8.80–13.90)	−28.8*

Incidence represented as estimates with 95% confidence interval.
*Nonoverlapping confidence intervals between 2010 and 2019.

Table 3. Incidence of Interphalangeal Joint Arthrodesis by Sex and Age Bracket

	IPJ Arthrodesis			IPJ Arthroplasty		
	2010 Incidence (per 1,000,000)	2019 Incidence (per 1,000,000)	% Change	2010 Incidence (per 1,000,000)	2019 Incidence (per 1,000,000)	% Change
Male				Male		
<40 y	5.8 (4.73–6.82)	3.7 (2.56–4.91)	−36.2	3.3 (2.43–4.17)	1.2 (0.51–1.82)	−63.6*
40–49 y	12.1 (9.44–14.84)	15.8 (9.98–21.64)	30.6	6.0 (4.08–7.88)	5.0 (1.72–8.33)	−16.7
50–59 y	24.8 (20.73–28.77)	29.8 (22.58–36.97)	20.2	14.5 (11.47–17.51)	8.0 (3.94–12.12)	−44.8
≥60 y	28.1 (22.40–33.76)	32.5 (19.02–46.02)	15.7	23.8 (16.11–31.51)	15.9 (5.41–26.33)	−33.2
Female				Female		
<40 y	2.8 (2.10–3.41)	2.6 (1.46–3.77)	−7.1	2.1 (1.52–2.63)	1.2 (0.48–1.94)	−42.9
40–49 y	20.5 (17.07–23.87)	14.3 (9.48–19.13)	−30.2	10.5 (8.07–12.83)	5.4 (2.39–8.45)	−48.6
50–59 y	77.8 (70.90–84.69)	73.7 (63.33–83.98)	−5.3	39.1 (34.15–43.96)	23.3 (17.33–29.23)	−40.4*
≥60 y	80.0 (70.93–88.99)	87.0 (69.21–104.83)	8.8	47.4 (39.30–55.46)	29.6 (19.52–39.72)	−37.6

Incidence represented as estimates with 95% confidence interval.
* Indicates nonoverlapping confidence intervals between 2010 and 2019.

respectively (from 18.1 to 26.9 per 1,000,000 and from 15.9 to 25.8). By 2019, rates of arthrodesis were relatively similar across all regions of the United States.

Arthroplasty

Case Volume and Incidence

In total, 32,005 IPJ arthroplasty procedures occurred in the database from 2010 to 2019. Both volume and incidence levels of IPJ arthroplasty showed mild fluctuations from year to year, which accumulated over the study timeframe to result in a significant decrease in both volume and incidence by about 25%–30% (Table 1; Fig. 1).

Sex

Looking across men and women for 2010 and 2019, the incidence of IPJ arthroplasty was higher for women in both 2010 and 2019, being performed about twice as often. There was a decrease in IPJ arthroplasty among women from 2010 to 2019 (16.0 per 1,000,000 to 11.4 per 1,000,000, with nonoverlapping confidence intervals). The incidence of IPJ arthroplasty among men also downtrended over the study period, albeit with overlapping confidence intervals (8.2 per 1,000,000 in 2010, to 5.2 in 2019).

Sex and Age

Stratifying incidence by sex and age showed that incidence of IPJ arthroplasty in 2010 was highest among women in the 60+ and 50–59 age categories specifically. Although the rates were still highest among these 2 age categories in 2019, the incidence values were lower than 2010, with nonoverlapping confidence intervals in the 50s age group (40% decrease, Table 3). Overall, all female age categories showed a downward trend in arthroplasty, with about a 40% decrease in rates, though only women in the 50–59 age group evidenced nonoverlapping confidence intervals. Men showed a similar pattern, with all groups showing a downward trend over time, though only the youngest group (<40s) evidenced nonoverlapping confidence intervals.

For women, the most notable increase in incidence with increasing age was between the 40s to 50s age brackets in both 2010 and 2019, with the second greatest being younger than 40 to 40s. Men showed a more gradual increase with increasing age, only showing a jump across age brackets for 40–50-year-olds in 2010, with no notable jumps in greater arthroplasty rates between adjacent age brackets in 2019.

Region

Looking across US regions, IPJ arthroplasty incidence was higher in the northeast and midwest in 2010, compared with the south and west. However, during the study period, incidence in the northeast and midwest decreased by 56.2% and 58.0%, respectively, becoming more similar to the south and west. By 2019, arthroplasty rates were between 6.4 and 12.7 per million within each US region.

DISCUSSION

During the past 2 decades, there has been debate surrounding IPJ arthroplasty outcomes, and indications for arthroplasty. Despite multiple initial reports of IPJ arthroplasty complications, such as implant breakage, loosening, and migration,[11,12,14,16,22,29–31] with some studies suggesting

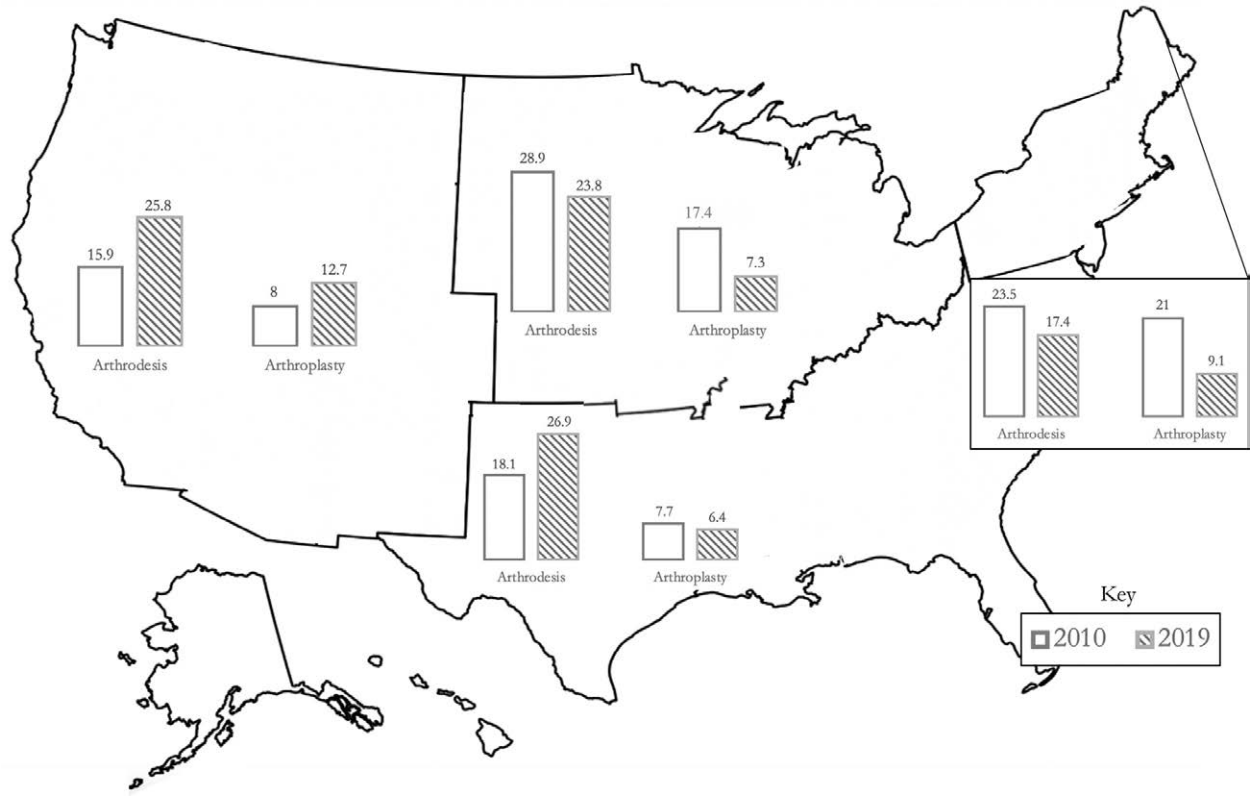

Fig. 2. Regional Incidence of IPJ arthrodesis and arthroplasty in 2010 and 2019.

Table 4. US Regional Incidence of Interphalangeal Joint Arthrodesis and Arthroplasty

	IPJ Arthrodesis			IPJ Arthroplasty		
	2010 Incidence (per 1,000,000)	2019 Incidence (per 1,000,000)	% Change	2010 Incidence (per 1,000,000)	2019 Incidence (per 1,000,000)	% Change
Region						
Northeast	23.5 (20.00–26.94)	17.4 (11.34–23.43)	−26.0	21.0 (17.45–24.53)	9.2 (5.11–13.21)	−56.2*
Midwest	28.9 (25.68–32.09)	23.8 (20.00–27.62)	−17.6	17.4 (14.11–20.67)	7.3 (5.11–9.50)	−58.0*
South	18.1 (16.74–19.55)	26.9 (22.08–31.72)	48.6*	7.7 (6.79–8.64)	6.4 (4.84–8.03)	−16.9
West	15.9 (14.04–17.69)	25.8 (19.15–32.45)	62.3*	8.0 (6.76–9.29)	12.7 (6.88–18.49)	58.8

Incidence represented as estimates with 95% confidence interval.
*Significance with nonoverlapping confidence intervals between 2010 and 2019.

superiority of arthrodesis due to this,[3] more recent studies have shown improvements in surgical technique and potentially a refining of indications, with improved outcomes and lower complication rates.[13,19,20,32–39] In light of this, our study sought to examine IPJ arthrodesis and arthroplasty utilization within the United States. From 2010 to 2019, our study found a steady decrease in IPJ arthroplasty rates. Overall, IPJ arthrodesis remained relatively stable during the study period.

Since IPJ arthroplasty was first introduced,[41] the benefits of increased motion and the concerns of instability, fracture, and reoperation have been debated. Historical reports showed promising outcomes and relatively low complications,[4,7,16,21–28] whereas reports in the first decade of the 21st century started to show higher rates of complications and concerning outcomes.[11,12,14,16,22,30,31] A series comparing IPJ arthroplasty to arthrodesis demonstrated potentially improved rates of pain and lower complications among arthrodesis, particularly in border digits.[3,28] However, recent studies,[13,19,20,32–39] including those examining border digits,[38] have shown more promising outcomes for arthroplasty. These findings can impact surgical decision-making. In a study from 2005 to 2011 using outpatient California and Florida surgery registries, IPJ arthroplasty procedures were found to peak in 2007, and decrease thereafter,[42] potentially influenced by the early reports. In another recent study querying patients with osteoarthritis and CPT codes of IPJ arthroplasty,[43] rates peaked around 2010, and downtrended subsequently (with the study reporting an overall annual growth rate of 2.4% from 2005 to 2013). In our study of more recent years, rates continued to downtrend. It is unclear whether this pattern will continue as complication rates decrease, surgical innovations continue to

emerge, and new material and design innovations continue to evolve.

To explore incidence in more depth, our study looked at specific subpopulations, including sex and age. We found higher rates of IPJ arthrodesis and arthroplasty among women. In the literature, women undergo IPJ arthroplasty more often than men, with 1 study reporting almost 4 times as many small joint (metacarpophalangeal and proximal interphalangeal joints [PIPJ]) arthroplasty procedures among women.[42] In our study, women had a higher incidence of IPJ arthroplasty in both 2010 and 2019, despite an overall decrease in rates over time. Interestingly, this decrease in arthroplasty was mirrored by a slight, though not significant, uptrend in arthrodesis. Overall, sex differences in IPJ arthrodesis also held, with the higher incidence in women in 2010 (28.7 versus 12.5 per 1,000,000 in men), staying relatively stable into 2019.

Prior literature has also looked at age breakdown among these procedures. Our study assessed incidence among age brackets (<40, 40–49, 50–59, and 60+ years). As expected, with increasing age, there was increasing incidence, though the most notable increases tended to be when moving from the 40s to 50s age brackets. In the study using outpatient California and Florida surgery registries,[42] age groupings were slightly different (5–19, 20–44, 45–64, 65–74, etc). In their study, the most substantial increase in PIPJ arthroplasty was from the 20–44 to 45–65 age brackets (316 to 2909 procedures, respectively; compared with 2098 procedures in the 65–74 age group). When considering arthroplasty rates among younger patients, it is important to note that younger patients are at greater risk for needing revision surgery and have lower 10-year implant survival.[20] Potentially aligning with this, arthroplasty incidence among young men (<40 years) decreased, with nonoverlapping confidence intervals, over our study timeframe, and rates among young women (<40 years) also decreased, albeit with overlapping confidence intervals.

Our study also explored differences across US regions in 2010 and 2019. Regional differences were found in 2010. Specifically, both procedures had a higher incidence (accounting for population size) in the midwest and northeast. In a Medicare database study from 2005 to 2013, before the dates of the current study, though overlapping slightly, rates of arthroplasty by region differed from our findings, with IPJ arthroplasty being more common in the south and less common the northeast.[43] Because that study included only patients on a Medicare plan, and ours includes public and private patients, it is possible that these databases may draw from different populations or miss certain subgroups. It is also possible that these trends can change from year to year, as our study only looked at 2 snapshots (2010 and 2019). In our study, the initial regional differences in 2010 did not continue into 2019, as incidence rates became relatively similar across regions for both arthroplasty and arthrodesis. Overall, trends across different regions of the United States are not well established.

Reasoning behind IPJ surgery trends could be multitude and may be patient-driven, clinician-driven, or due to changes in preventative treatments and arthritis etiologies. Exploring this in more depth could be an interesting avenue for future research. For example, the overall number of IPJ procedures sought by patients with rheumatoid arthritis may be changing,[2,19,20,38] with surgery sought less commonly.[40] Although underlying diagnosis was not collected in our study, this is an avenue for future research and could be interesting, as our study found an overall decrease in arthroplasty rates, without a clear concomitant rise in arthrodesis. It is possible that advances in medical treatment, and efforts toward presurgical patient optimization, could partly impact surgical trends. Furthermore, weighing the concern for complications against the joint-sparing benefits of IPJ arthroplasty is important to consider. In a survey of patients with IPJ arthritis, the characteristics of surgical intervention rated most important were the potential effects of surgery on joint stiffness and grip-strength, with intermediate importance being need for future surgery and cost.[44] Therefore, the important characteristics best matched arthroplasty, also known as ability to preserve joint motion while maintaining strength. It will be interesting to see how these influence surgical trends, given recent reports of improved IPJ arthroplasty outcomes.[13,19,20,32–39] Overall, advancements in treatment, changes in patient preferences, and other etiologic factors may influence and underlie changing trends.

Although this study contributes population-level surgical trends to the current literature, it is not without limitations. Data were drawn from the IBM Marketscan database, which contains information from insured populations and, thus, may limit generalizability of the findings to the entire US population. This may be of particular consideration for working populations, as workers compensation is not included. This is also important to keep in mind when considering incidence. Although IBM MarketScan discharge weights were used to try to better estimate true population values, incidence calculations utilize US Census population values, which include the entire population, including uninsured. Therefore, true incidence among the insured population is likely slightly higher than calculated values. Next, data in our study were collected using CPT codes and, therefore, rely on accurate medical coding; omitted or incorrect coding may result in missed patients. Furthermore, the CPT codes for IPJ arthroplasty and arthrodesis include both proximal and distal IPJs. Therefore, we are unable to distinguish between these joints in our analyses, making direct comparison of arthrodesis and arthroplasty rates challenging, as we cannot directly compare PIPJs and/or DIPJs. Although arthroplasty of the DIPJ has been previously described,[45] arthrodesis of this joint is more commonly performed. In our study, rates of arthrodesis were higher than those of arthroplasty in all years, which may be partly due to DIPJ procedures. This limitation raises an interesting question on how we code for these procedures, and whether the surgical effort is similar enough that the code should remain as is, or if it would be helpful for the coding to differentiate between DIPJ and PIPJ, even if partly for improved data and tracking. For now, prospective studies

that specifically note the joint being intervened upon, or chart reviews that include operative reports, may be necessary for this level of detail. Our study also does not provide information on type of arthroplasty implant, limiting assessments of incidence by type. Finally, our study did not draw ICD-codes and thus does not have data on underlying etiology, nor does it have data on preoperative optimization. Although this was not the primary objective of this investigation, this information may be interesting for future research.

In summary, IPJ arthrodesis levels have stayed relatively stable over the study period. Conversely, IPJ arthroplasty showed a slight decline. Overall, this decline was present among the majority of sex and age subgroups, though particularly prominent among elder women. Regional incidences of IPJ arthrodesis and arthroplasty appear to be converging, with rates of each becoming more similar across regions in 2019 compared with 2010. We hope that shedding light on the latest procedure trends can help us better understand standards of practice across the country, fuel research on factors that influence surgical choice, and help anticipate future trends in surgical management of small joints.

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DISCLOSURES

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