

Research Article

Wrist Arthroplasty Leads to Better Outcomes than Arthrodesis for Treatment of Patients with Advanced Rheumatoid Arthritis of the Wrist: A Review of Literature

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Abstract

Purpose: The aim of this review was to search the literature for evidence comparing outcomes and complications between arthroplasty (joint replacement) and arthrodesis (joint fusion) in treating elderly with advanced rheumatoid arthritis of the wrist, then to critically appraise the evidence, and at the end to assess how the evidence could be implemented in the treatment of these patients.

Methods: OVID Medline and Pub Med were the databases used for the search. The inclusion criteria included only studies comparing arthrodesis to arthroplasty in elderly patients with advanced rheumatoid arthritis of the wrist. Time limit of 15 years was made and only studies in English were included. Primary outcomes were functional outcome and symptomatic relief while the secondary outcome was cost of treatment.

Results: Pub Med showed the five studies resulted in Medline in addition to another one. None of the studies revealed was a randomized controlled study (RCT). One was a systematic review, another was a retrospective study and one was cost effectiveness. Eligible studies were critically appraised using the Critical Appraisal Skills Program checklists.

Conclusion: The review supported the use of wrist arthroplasty as a valid option for treating advanced rheumatoid arthritis of the wrist.

Keywords: Rheumatoid wrist; Arthroplasty; Arthrodesis; Fusion

Introduction

Rheumatoid arthritis is a chronic inflammatory condition of unknown a etiology, which can be disabling causing up to 35% of patients with 10 years of symptoms to early retire [1], and carries a high mortality rate [2]. It targets mainly the synovial membrane and articular cartilage of joints leading to joint deformity and instability [3]. Genetic, immunological and environmental factors are thought to cause the disease in such a way that susceptible genes are triggered by infection or environmental factors leading to inappropriate immune response attacking the joints.

Around 1% of general population is affected [4], in the UK it is estimated to affect about 0.8% of the population [5] and in some countries, where it is prevalent, it affects about 2% of population above 60 years [6]. Though highest rates are in north Europe and America some studies are showing decrease of incidence in these regions [7]. It is more common in white race [8], affecting elderly in the 5th and 6th decade [4] with women being affected 3 folds more than men [7].

Wrist and hands are the most common joints affected in rheumatoid arthritis such that by 4 years of the onset of the disease more than 90% of patients would show symptoms of involvement of at least one of these joints [9]. Affection of carpal ligaments and tendons around the wrist would lead to radial deviation of radio carpal joint with ulnar deviation of the fingers at the MCP joint, subluxation of

distal ulna and dropped fingers resulting in a zigzag deformity [10], or what is known as caput ulnae syndrome [11]. Half of the patients might have systemic or extra articular manifestations (ExRA). Nodules are the most common ExRA [12] with the cardiovascular system being the most affected [13], and this might be the reason why these patients show a higher mortality rate than the non-ExRA subgroup [12,14].

Patient presents complaining of painful, swollen, stiff joints, especially after period of rest, and even obvious deformity in late presentations. It is characterized by periods of remission and activity, which can be assessed using scores as the Disease Activity Score (DAS28) [15].

No single test is diagnostic for RA. HLA-DR4 is positive in almost half of the patients with RA [16] and rheumatoid factor (RF) in about 90% [17]. Diagnosis is usually done by clinical picture supported by X-Ray which is a gold standard in RA [18], showing decrease joint space, marginal bony erosions, articular destruction and obvious deformity. The American College of Rheumatology set some criteria to help the early diagnosis of rheumatoid arthritis which would give a chance to medical treatment to minimize the permanent damage caused by the disease [19].

Patients should be aware that here is no cure for rheumatoid arthritis. The main aim of treatment is trying to modify the course of the disease medically and at the same time offering the patients

Table 1: PICO model.

	Paper 1	Paper 2
Research question	Not clear	Not clear
P	Patients with advanced rheumatoid arthritis of the wrist	ALL patients with advanced RA of the wrist between 1997-2001
I	Arthrodesis	Arthroplasty
C	Arthroplasty	Arthrodesis
O	- Pain - Motion - Complications - Satisfaction	- DASH - PRWE - Patient satisfaction

painless and functioning joints which would necessitates a multidisciplinary team (MDT) approach [4].

Though surgery isn't usually needed in the early stages of the disease, early referral for surgical evaluation especially for patients who are not responding well for medical treatment or having increasing deformity, would benefit the patients [4,10,20]. Surgical treatment for rheumatoid wrist in the early stages tends to be mainly symptomatic as synovectomy and tendon transfer, while in more advanced cases a salvage procedure as arthrodesis (partial/complete) or arthroplasty would be needed [10]. One third of patients would undergo at least one surgery along the course of the disease with total joint arthroplasty being the commonest [21].

Table 2: Search terms.

Key words used (in titles)	MEDLINE (Ovid)	Pub Med
Wrist	5850	6424
Rheumatoid or RA	51850	54846
Arthrodesis or fusion	32088	34669
Arthroplasty or replacement	60932	65016
Add all the above	9	10
Limit to English	9	10
Last 20 years (1993)	5	6

The aim of this review was to search the literature for evidence comparing outcomes and complications between arthroplasty (joint replacement) and arthrodesis (joint fusion) in treating elderly with advanced rheumatoid arthritis of the wrist, then to critically appraise the evidence, and at the end to assess how the evidence could be implemented in the treatment of these patients. A foreground question was used, as it was meant to influence clinical decision, and it was structured according to the Population Intervention Comparison Outcome (PICO) framework [22] "Would wrist arthroplasty as compared to wrist arthrodesis for treatment of advanced rheumatoid arthritis in the elderly, result in better functional and clinical outcomes?" (Table 1).

Table 3: Demographic data and selection criteria in both studies.

		Paper 1	Paper 2
Number	Total	1363	51
	Arthrodesis	860	24
	Arthroplasty	503	27
Age			
Arthrodesis		57.2 years	52 years
Arthroplasty		55.8 years	51 years
Gender			
Arthrodesis		F/M: 79%	F/M: 16/6
Arthroplasty		F/M: 79%	F/M: 27/0
Follow up		At least 1 year (average 4.5)	1-5 years
Inclusion		-Primary data -Human -English language publication -Mean follow-up 1 yr -80% of patients with RA -Metal-plastic total wrist prosthesis or total wrist arthrodesis -Complications and frequency of complications documented -Revisions and additional operations reported -At least 10 patients included in study	- All patients with symptomatic, severe wrist arthritis presenting to one of the authors between 1997 and 2001
Exclusion		-Review article -Animal or cadaveric studies -Non-English publication -Mean follow-up 1 yr -Unclear diagnoses, 80% of patients with RA or unable to separate outcomes for RA patients -Other procedures -Complications unclear or frequency of complications not specified -Revision operations and additional procedures unclear or not specified -Case report or fewer than 10 patients included in study -Study of revision operations after failed total wrist arthroplasty or arthrodesis	- Non-mentioned

Materials and Methods

Eligibility

OID Medline and Pub Med were the databases used for the search. The references of the found studies were screened for any missed studies. The search was done by 15 April 2014.

Study identification

The title and abstract of each study on our results list were reviewed as to their potential eligibility. Full text papers of the relevant studies were ordered or downloaded and were reviewed against the eligibility criteria. The inclusion criteria included only studies comparing arthrodesis to arthroplasty in elderly patients with advanced rheumatoid arthritis of the wrist. Time limit of 15 years was made and only studies in English were included. Primary outcomes were functional outcome and symptomatic relief while the secondary outcome was cost of treatment. The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines [23], were strictly followed in reporting our review.

Results

In an attempt to reach the best available evidence a strategy for the search was used. Key words were targeting the primary problem, which is treatment of advanced rheumatoid arthritis in elderly using either arthrodesis or arthroplasty. For both databases, the following terms were used in the search (Table 2). Pub Med showed the five studies resulted in Medline in addition to another one [24]. None of the studies revealed was a randomized controlled study (RCT). One was a systematic review [25], another was a retrospective study [26], one was a cost effectiveness [27], two were expert reviews [24,28] and the last one was a case study [29]. The systematic review, the retrospective study (Table 3), and the cost-utility would be critically appraised, the expert reviews, as they have the least weight in the hierarchy of evidence [30], and the last case study, as it was regarding a revision procedure, shall be excluded. Eligible studies were critically appraised using the Critical Appraisal Skills Program checklists.

Paper 1

A systematic review of total wrist arthroplasty compared with total wrist arthrodesis for rheumatoid arthritis [25]: The first study is a systematic review published in 2008 under the management of Rheumatoid Wrist in the textbook "Plastic and Reconstructive Surgery".

It is an appropriate study design, which addresses the functional outcomes in patients with advanced rheumatoid arthritis of the wrist treated with either wrist arthrodesis or arthroplasty. It also looked at complications, revision surgeries and patients' satisfaction.

Though the study was aiming to compare the outcomes of both modalities of treatment helping decision making in treating rheumatoid arthritis of the wrist, the high variety of procedures achieving arthrodesis or arthroplasty made it hard to formulate a focused research question and due to the heterogeneity of the available data, it was not possible to do statistical analysis for the results, that's why the author chose to do a systematic review rather than a meta-analysis.

The systematic review looked at all the information available on

Table 4: Patients utility weight.

	Non-operative	Arthrodesis	Arthroplasty	Utility weight
Patient	12.3 QALY	15.3 QALY	20.4 QALY	0.41
Clinicians	16.5 QALY	24.0 QALY	25.5 QALY	0.55

wrist arthrodesis and arthroplasty in the treatment of rheumatoid arthritis of the wrist in general no specific age group or clear outcomes, whether primary or secondary, were identified.

Only one database was used in the search (Medline), which can miss studies not available on this specific database but they tried to overcome this by screening the references of the resulted studies for other possible missed citations. Time limit was set to 40 years (1966-2006) which seems very reasonable and considering the rapid development of the arthroplasty prostheses, the author identified the potential bias that can occur on the overall results when including early arthroplasty studies, which used implants that might not be even in use anymore, together with the more recent ones so arthroplasty results were evaluated combined and separately for the latest generations of prostheses.

Only studies in English language were included, which may be due to funding reasons regarding translation, but how many non-English studies were excluded and whether any of them is worth considering was not mentioned.

Search terms for each procedure were mentioned and inclusion and exclusion criteria were clearly identified and well presented in a table which all helps in the reproducibility of the research. Complications, as an important factor in decision making when considering a surgical intervention, were well defined and studies not clearly mentioning they were excluded.

The study provided a flow diagram for the search strategy with a well descriptive paragraph regarding reasons of exclusion making the choice of studies easy to follow. No randomized control trials were available for the review and apart from one retrospective cohort study [26], which shall be discussed later, other studies were multiple nonrandomized case series.

Searching only one database with exclusion of non-English studies, lack of personal contact with experts regarding the subject and not searching unpublished studies as well as the published ones would question whether all important relevant studies were included or not. After the secondary search nothing was mentioned regarding the assessors who assessed the titles and abstract or did the articles review. It was clearly declared that there was no potential conflict of interest.

The systematic review, as expected, led to increase of the overall sample size and the demographic data was consistent with that of the disease with women in their 6th decade being affected 3 folds more than men.

Outcome measures used were very suitable and targeting the aim of the study; pain is the main reason why a salvage procedure would be offered to the patient, motion is the main advantage of doing arthroplasty, complications are always important in surgical procedures and patients' satisfaction which is eventually the main aim of any modality of treatment and the results for these measures

were well presented in tables.

Most of the included studies lacked a proper preoperative assessment so that the author assumed the level of preoperative pain and range of movement was significant without having any reported scores for these parameters and though most the studies recorded the postoperative results no validated score systems were used.

The heterogeneity of the data prevented statistical analysis of the results in a meta-analysis and hence no statistical significant difference could be detected.

The gap in the available evidence was detected by the review and limitations regarding the study and available studies were identified along the review with efforts to eliminate possible bias of the results, which was not possible completely, and the author's conclusion that more well-structured studies are needed is appropriate.

Paper 2

Comparison of arthroplasty and arthrodesis for the rheumatoid wrist [26]: This study, which was included in the discussed systematic review, was selected, as it was directly comparing arthrodesis and arthroplasty of rheumatoid wrist. Though it's a retrospective cohort study, but in the absence of RCTs, it would be considerable level of evidence as it follows RCT in the hierarchy of evidence [30].

The abstract was well structured mentioning the aim of the study at the beginning. The current practice with potential benefits and complications of the procedures was mentioned in the introduction alongside with the aim of the study and the tested hypothesis was that the wrist arthroplasty, using the Universal prosthesis, would show better functional outcomes that can justify the costs and risks of the procedure. The study obtained approval from the Institutional review board approval of each institution.

The main study group, which was the arthroplasty one, was a non-randomized group of patients operated upon in one institute then four other surgeons in other institutes, who didn't do arthroplasty in their practice, were asked to provide the comparison group. The level of experience of the surgeons was not mentioned but it seemed that arthroplasty isn't common even among hand surgeons, which would make the study more experimental than pragmatic.

Patients in the first group were not randomized instead they were offered a treatment option and the decision was left for them to choose and surprisingly all of them chose the arthroplasty but still no information on the consenting process or how the option was presented to the patients was mentioned.

Some of the outcome measures and classifications used were validated; DASH, PRWE and Wrightington classification, while the medication score and the questionnaire sent for the patients were not, good description of the outcome measures was provided and was well illustrated in tables.

Numbers of patients needed in the study were not decided through a power calculation instead all patients presenting to one author within a time frame were included without any clear inclusion or exclusion criteria and the other surgeons were asked to provide the matching group.

More care was given for the analysis of the results, details

regarding the arthroplasty and the follow up plan was not mentioned in this study but in another one were those patients were enrolled in a prospective non-comparative study [31], which would question the external validity and replication of the procedures.

No statistical differences between the two groups were detected when analyzing the results, instead there was just a trend favoring the arthroplasty regarding the personal hygiene and fastening buttons. No declaration regarding absence of conflict of interest was mentioned.

Paper 3

A cost utility analysis of non-operative management, total wrist arthroplasty, and total wrist fusion in rheumatoid arthritis [27]: The third paper discussed is one looking at the cost of different ways of treating advanced rheumatoid arthritis of the wrist, the two modalities included in our main question beside the non-surgical option of treating the same condition.

Cost utility analysis is an economic assessment method used to estimate the ratio between the cost and the benefit of a procedure presenting added years of full health measured in QALY (Quality Adjusted Life Year), which is estimated years of life multiplied by utility weight (in this study was TTO, which is how many years of life with advanced rheumatoid wrist the patient would trade for a less symptomatic wrist). Though cost-utility analysis allow comparison between different treatment methods but it relies on patients' preferences, which is very subjective and hard to measure.

The study had a well-structured abstract with a clear aim mentioned at the beginning. The three possible treatments for the condition were included in the study, two surgical, fusion and arthroplasty, which were the main concern of our study together with the non-operative management, which is always an option in treatment.

The study recognized that the perspective, which is the way of analyzing the cost-effectiveness, should cover all possible consequences of the treatment not only the narrow scope of the medical costs, but as rheumatoid arthritis is a widely disabling disease it was concluded, based on other studies, that patients presenting with advanced condition in the wrist will not be participating in paid employment and most likely to be retired, that's why the productivity gain or loss was not included in the general cost calculations, but apart from that the calculation included all relevant medical costs from surgeon and anesthesia fee, surgery center cost and hardware cost were included, besides a good estimate to the cost of non-operative treatment was done.

A clear diagram for decision tree was given but as there were no RCTs available, as revealed by our study, the possible complications were based on the published literature of which the systematic review discussed earlier was the best available.

Time trade-off (TTO) was used as a direct method of measuring the utility weight that would be expressed as Quality-Adjusted-Life-Years (QALYs).

Uncertainty in the literature regarding the rate of complications of the two surgical procedures was identified and together with the remaining years of life, as QALY was used, were considered as variables that can change the outcome measures resulting in an

adequate sensitivity analysis.

Patients as well as clinicians were included in the study and as there was no enough evidence in the literature, the analysis considered the extreme scenarios, patients living only one year or living 40 years with multiple revisions and final arthroplasty, and even considered the patients' utility weight (0.41), which would result in higher differences compared to results based on clinicians respond (0.55) (Table 4).

Incremental cost of arthroplasty compared with non-operative treatment was \$2,281/QALY and \$2,328/QALY respectively and even when adding an intense hand therapy course, not needed in arthrodesis, the cost would be \$3,034/QALY.

One interesting finding in this study was the difference in utility weight between patients and clinicians which would suggest that either the pain and importance of keeping some function of the wrist is not well appreciated by the clinicians or clinicians feels that operative complications still outweigh the benefits of the surgery.

Patients covered in this study are more or less similar to our served population and though medical expenses can vary from one country to the other we do believe that the figures given in this study gives a reasonable estimate that can be considered in our setting.

Discussion

Systematic review is a method to have an overview of the published literature on a specific question, if proper studies were found it becomes an important tool in evidence-based decision making and if not it would identify the need of future research. When separate studies include few numbers of patient, systematic reviews help to increase sample sizes giving more power to the concluded results.

Cavaliere and Chung showed in their systematic review that there was no difference between arthroplasty and arthrodesis in treatment of advanced rheumatoid arthritis of the wrist regarding pain, range of movement, complications including revision surgeries and patient satisfaction but, as the studies reviewed were not well-structured and lacked lots of documentation which limited the data gained, detecting significant differences through statistical analysis was not possible [27].

When movements were assessed it was compared to the normal functioning range, which is not practical when considering rheumatoid patients. On the other hand, retrospective studies records data through reviewing patients' notes, which would depend on accuracy of documentation, or asking patients to fill questionnaire depending on their memory making it liable to recall bias. Murphy et al tried to compare the results of one group of patients enrolled in a prospective study for arthroplasty to another matched group retrospectively. In this study no significant differences were detected just positive trends in favor of the arthroplasty regarding personal hygiene, and the prospective study results [31], showed better range of movements in the same group.

Pain and movements are the main clinical outcomes targeted when treating rheumatoid wrist. Arthrodesis was traditionally offered to these patients aiming to achieve a painless wrist but on the expense of loss of movements [32,33]. In a recent study assessing the

functional outcomes after bilateral arthrodesis [34], it was concluded that bilateral total wrist arthrodesis improved pain while enabling patients with severe carpal arthrosis to maintain a satisfactory level of extremity function and quality of life. Patients adapted and were satisfied with functional capabilities.

Rheumatoid arthritis is a disabling condition that affects not just the wrist but other joints in the upper limb as well, so fusing the wrist would make patients daily activity and personal care harder, which significance for the patients, as shown by the cost-utility study [27], might be underestimated, that's where the role of arthroplasty comes. Arthroplasty aims to provide fairly painless and mobile wrist not to the normal range but enough for patients' daily needs. Early results for arthroplasty were not promising, with high rates of failure but more recent results are promising [33,35,36].

When adopting a treatment option, it should be ideally both clinically and cost effective. Clinically, many factors may influence the final outcome of an arthroplasty within the rheumatoid wrist. These factors should be taken into consideration while planning for wrist replacement [37]. Patient's motivation, pain threshold and tissue elasticity are unique to each patient, and are critical of the surgical result. The state of the hand and the degree of soft tissue and bony destruction is an influential factor leading to the final outcome [37]. It has been suggested that wrist replacement is recommended for those patients with greatest joint destruction and deformity [38], but the results of total wrist arthroplasty may improve significantly if surgery is done at an early stage when the bone stock is good and soft-tissue destruction less [33]. The postoperative therapist may influence the outcome as much as the surgeon himself [37]. The type of the prosthesis could almost lead to an unsatisfactory result as its longevity still remains unclear. However, fourth generation implants have had better durability with survivorship reported to be greater than 90% [35].

Concerning the cost effectiveness, the National Institute for Health and Care Excellence (NICE) threshold range for adopting new treatment is £20,000 to £30,000 per QALY [39], and as reported by the third study wrist arthroplasty falls far below this range. And though wrist arthroplasty in rheumatoid patients seems to be within the reasonable cost range, it needs more evidence to support this clinically and a well-structured RCT would be needed.

Conclusion

For now, we think wrist arthroplasty can be a valid option for treating advanced rheumatoid arthritis of the wrist, which needs a skilled surgeon and we would consider recording functional scores for our patients which can add to the present available evidence.

References

1. Allaire S, Wolfe F, Niu J, Lavalley MP. Contemporary prevalence and incidence of work disability associated with rheumatoid arthritis in the US. *Arthritis Rheum.* 2008; 59: 474-480.
2. Hochberg MC, Spector TD. Epidemiology of rheumatoid arthritis: update. *Epidemiol Rev.* 1990; 12: 247-252.
3. Hochberg MC. Adult and juvenile rheumatoid arthritis: current epidemiologic concepts. *Epidemiol Rev.* 1981; 3: 27-44.
4. Ilan DI and Rettig ME. Rheumatoid arthritis of the wrist. *Bull Hosp Jt Dis.* 2003; 61: 179-185.

5. Symmons D, Turner G, Webb R, Asten P, Barrett E, et al. The prevalence of rheumatoid arthritis in the United Kingdom: new estimates for a new century. *Rheumatology (Oxford)*. 2002; 41: 793-800.
6. Rasch EK, Hirsch R, Paulose-Ram R, Hochberg MC. Prevalence of rheumatoid arthritis in persons 60 years of age and older in the United States: effect of different methods of case classification. *Arthritis Rheum*. 2003; 48: 917-926.
7. Doran MF, Pond GR, Crowson CS, et al. Trends in incidence and mortality in rheumatoid arthritis in Rochester, Minnesota, over a forty-year period. In: *Arthritis Rheum. United States*. 2002; 46: 625-631.
8. MacGregor AJ, Riste LK, Hazes JM, Silman AJ. Low prevalence of rheumatoid arthritis in black-Caribbeans compared with whites in inner city Manchester. *Ann Rheum Dis*. 1994; 53: 293-297.
9. Horsten NC, Ursun J, Roorda LD, Schaardenburg DV, Dekker J, et al. Prevalence of hand symptoms, impairments and activity limitations in rheumatoid arthritis in relation to disease duration. *J Rehabil Med*. 2010; 42: 916-921.
10. Trieb K. Treatment of the wrist in rheumatoid arthritis. In: *J Hand Surg Am. United States*. 2008; 33: 113-123.
11. Norris SH. Surgery for the rheumatoid wrist and hand. *Ann Rheum Dis*. 1990; 49: 863-870.
12. Cojocar M, Cojocar IM, Silosi I, Vrabie CD, Tanasescu R. Extra-articular Manifestations in Rheumatoid Arthritis. *Maedica*. 2010; 5: 286-291.
13. Hochberg MC, Johnston SS, John AK. The incidence and prevalence of extra-articular and systemic manifestations in a cohort of newly-diagnosed patients with rheumatoid arthritis between 1999 and 2006. *Curr Med Res Opin*. 2008; 24: 469-480.
14. Turesson C, Jacobsson L, Bergstrom U. Extra-articular rheumatoid arthritis: prevalence and mortality. *Rheumatology (Oxford)*. 1999; 38: 668-674.
15. Heijde DM, Hof M, Riel PL, Putte LB. Development of a disease activity score based on judgment in clinical practice by rheumatologists. *J Rheumatol*. 1993; 20: 579-581.
16. Zhou Y, Tan L, Que Q, Cai L, Cao L, et al. Study of association between HLA-DR4 and DR53 and autoantibody detection in rheumatoid arthritis. *J Immunoassay Immunochem*. 2013; 34: 126-133.
17. Choe JY, Bae J, Lee H, et al. Relation of rheumatoid factor and anti-cyclic citrullinated peptide antibody with disease activity in rheumatoid arthritis: cross-sectional study. *Rheumatol Int*. 2013; 33: 2373.
18. Eiken O, Haga T, Salgeback S. Assessment of surgery of the rheumatoid wrist. *Scand J Plast Reconstr Surg*. 1975; 9: 207-215.
19. Aletaha D, Neogi T, Silman AJ, et al. 2010 Rheumatoid arthritis classification criteria: an American College of Rheumatology/European League Against Rheumatism collaborative initiative. *Arthritis Rheum*. 2010; 62: 2569-2581.
20. Rosen A, Weiland AJ. Rheumatoid arthritis of the wrist and hand. *Rheum Dis Clin North Am*. 1998; 24: 101-128.
21. Wolfe F and Zwiilich SH. The long-term outcomes of rheumatoid arthritis: A 23-year prospective, longitudinal study of total joint replacement and its predictors in 1,600 patients with rheumatoid arthritis. *Arthritis Rheum*. 1998; 41:1072-1082.
22. Sackett DL, Rosenberg WM, Gray, Haynes RB, Richardson WS. JA. Evidence based medicine: what it is and what it isn't. 1996. *Clinical Orthopedics & Related Research*. 2007; 455: 3-5.
23. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLOS Med*. 2009.
24. Cavaliere CM, Oppenheimer AJ, Chung KC. Reconstructing the rheumatoid wrist: a utility analysis comparing total wrist fusion and total wrist arthroplasty from the perspectives of rheumatologists and hand surgeons. In: *Hand (N Y). United States*. 2010; 5: 9-18.
25. Cavaliere CM, Chung KC. A systematic review of total wrist arthroplasty compared with total wrist arthrodesis for rheumatoid arthritis. In: *Plast Reconstr Surg. United States*. 2008; 122: 813-825.
26. Murphy DM, Khoury JG, Imbriglia JE, Adams BD. Comparison of arthroplasty and arthrodesis for the rheumatoid wrist. In: *J Hand Surg Am. United States*. 2003; 28: 570-576.
27. Cavaliere CM, Chung KC. A cost-utility analysis of nonsurgical management, total wrist arthroplasty, and total wrist arthrodesis in rheumatoid arthritis. In: *J Hand Surg Am. United States*. 2010; 35: 379-391.
28. Cavaliere CM, Chung KC. Total wrist arthroplasty and total wrist arthrodesis in rheumatoid arthritis: a decision analysis from the hand surgeons' perspective. In: *J Hand Surg Am. United States*. 2008; 33: 1744-1755.
29. Mutimer JN, Giddins GE. Maintaining wrist function in severe rheumatoid arthritis: A case study of revision Swanson wrist arthroplasty staged via a wrist fusion in rheumatoid arthritis. In: *Hand Surg. Singapore*. 2002; 7: 183-185.
30. Greenhalgh T. How to read a paper. Getting your bearings (deciding what the paper is about). *BMJ*. 1997; 315: 243-246.
31. Divilbiss BJ, Sollerman C, Adams BD. Early results of the Universal total wrist arthroplasty in rheumatoid arthritis. In: *J Hand Surg Am. United States*. 2002; 27: 195-204.
32. Stanley JK and Tolat AR. Long-term results of Swanson silastic arthroplasty in the rheumatoid wrist. *J Hand Surg Br*. 1993; 18: 381-388.
33. Takwale VJ, Nuttall D, Trail IA, Stanley JK. Biaxial total wrist replacement in patients with rheumatoid arthritis. Clinical review, survivorship and radiological analysis. *J Bone Joint Surg Br*. 2002; 84: 692-699.
34. Wagner ER, Elhassan BT, Kakar S. Long-term functional outcomes after bilateral total wrist arthrodesis. *J Hand Surg Am*. 2015; 40: 224-228.
35. Nair R. Survivorship in total wrist arthroplasty: a literature review. *Current Orthopedic Practice*. 2016; 27: 93-97.
36. Sagerfors M, Gupta A, Brus O, Pettersson K. Total Wrist Arthroplasty: A Single-Center Study of 219 Cases With 5-Year Follow-up. *J Hand Surg Am*. 2015; 40: 2380-2387.
37. Nalebuff EA. Factors influencing the results of implant surgery in the rheumatoid hand. *J Hand Surg Br*. 1990; 15: 395-403.
38. Gellman H, Hontas R, Brumfield RH, Tozzi J, Conaty JP. Total wrist arthroplasty in rheumatoid arthritis. A long-term clinical review. *Clin Orthop Relat Res*. 1997; 342: 71-76.
39. Health inequalities and population health. NICE local government briefings.