



Early Diagnosis of Rheumatoid Arthritis of the Wrist Using Power Doppler Ultrasound: A Review

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Abstract. Rheumatoid joint pain is ongoing severe infection that can influence joints as it were. This condition can harm different organ frameworks like skin, eyes, lungs, heart, and blood vessels. Rheumatoid joint pain, an immune system sickness, happens when the safe framework incidentally goes after its body tissues. Rheumatoid joint inflammation goes after the coating of the joints, causing a difficult expanding that can prompt bone deterioration and joint deformity. Ultrasound imaging is utilized for the early discovery of rheumatoid joint pain in the wrist. RA causes disfigurements in the patient's wrists, causing unbearable delicacy and enlarging in the joints. Clinical pictures, for example, X-beams, Ultrasound Power Dopplers assume a fundamental part in the early recognition of RA on the wrist. In any case, the as of late presented simulated intelligence (computerized reasoning) innovation further improves the capacities of imaging apparatuses. We support the exact determination of clinical experts. Picture catch utilizing simulated intelligence can extraordinarily assist with mechanizing the checking system, accelerate patient finding, and empower early identification and treatment to forestall distortions. Computer-based intelligence can likewise further develop work productivity through precise determination. Furthermore, the computerised platform helps radiologists with chasing after clinical decisions (i.e.) about contamination following and prognosticate. We have in like manner analysed the different segmentation methodologies used in clinical image management.

Keywords: Power Doppler Ultrasound Imaging · Early Diagnosis · Rheumatoid Arthritis in the wrist · Segmentation Techniques

1 Introduction

Rheumatoid Joint pain (RA) [14] produces disfigurements in patients' wrist [2, 6] and leads to horrifying agony, delicacy and enlarging in the joints. The special type of Ultrasound used to diagnose RA is Musculoskeletal Ultrasound. In the recent years, Power Doppler Ultrasound has proved to be an effective imaging modality for diagnosing RA disease activity at small-joint level, by detecting short-term reduction in synovial perfusion and showing underestimated persistence of active synovitis in patients with chronic

arthritis receiving steroids or biological treatment. Power Doppler Ultrasound is one among the other modalities such as Colour Doppler and Spectral Doppler Ultrasound in diagnosis of RA. In addition to these reasons, there are numerous advantages using ultrasound such as, easily affordable and available in most of the hospitals and diagnostic centres, it is feasible and portable, it is non-invasive and free of harmful ionizing radiations, it has non thermal effects and non-destructive testing, it is non-surgical and captured in real time which is an added advantage. A person with RA will likewise see knobs shaping close to the wrists, which are minor, strong knocks. Of the 291 ailments considered around the world, RA [1] was positioned as the 42nd, the most supporter of worldwide handicap. 46 people out of 100 individuals were worldwide impacted with RA [25]. It has been far and wide in India lately. Around the world, the yearly occurrence of RA [11] is around 3 for every 10,000 populace [4], the pervasiveness is around 1%, increments with age, and tops between the ages of 35 and 50. In India, around 1% of the populace experiences rheumatoid joint pain. It is assessed that almost 10,00,000 individuals experience the ill effects of this sort of joint pain. Most of individuals experiencing rheumatoid joint pain [3] have a place with the youthful age gathering of 20–40 years.

Ultrasound images are utilized to distinguish Rheumatoid joint [32] pain in the wrist at an early stage. The extraordinary sort of Ultrasound [5] used to analyze RA [23] in outer muscle Ultrasound. Lately, Power Doppler Ultrasound has ended up being a successful imaging methodology for diagnosing RA[7] sickness action at small-joint level, by identifying a short-term decrease in synovial perfusion [8] and showing underrated constancy of dynamic synovitis in patients with ongoing joint pain getting steroids or natural therapy. Power Doppler Ultrasound [5, 31] is one among different modalities like Variety Doppler and Phantom Doppler Ultrasound in the conclusion of RA [4]. Despite these reasons, there are different advantages using ultrasound, for instance, successfully sensible and open in most of clinical facilities and expressive centers, it is reachable and adaptable, it is easy and freed from hazardous ionizing radiations, it has non-warm effects and non-shocking testing, it is non-cautious and gotten ceaselessly which is an extra advantage.

2 Methodology

For this review of the literature, a literature search was conducted using Elsevier and PubMed, and all pertinent papers from 2008 through 2021 were compiled. Rheumatoid Arthritis, Power Doppler Ultrasound[10], Musculoskeletal Ultrasound [32], Imaging Techniques [33], Early Diagnosis, Deformities [3], and Synovitis [3], along with Segmentation [24, 31, 33] Techniques, are the primary terms used in this work. There were 40 studies total, and 24 of them dealt with rheumatoid arthritis [30] and power doppler ultrasound [10].

2.1 Literature Review

Power Doppler Ultrasound was seen as seriously convincing and exact in diagnosing dynamic Synovitis in RA patients in Clinical Decrease and early ailment. Ultrasound can be considered as an innocuous gadget in the finish of synovitis in early RA and

help in the medicinal decision in the organization of disorder at an earlier stage [2]. Deformations caused in the hand and wrist due to Rheumatoid Joint pain (RA) and the unavoidable harm caused in the high-level phases of RA. The significant road obstruction to a viable reaction to treatment could emerge from illness-related or treatment-related multisystem issues like cardiovascular, and gastrointestinal sicknesses, osteoporosis, pneumonic association, repetitive contaminations, neoplastic problems, and renal and mental entanglements. The US is a painless, reproducible, non-transmitting, and somewhat economical method used to recognize, dissect, and evaluate both the irritation of joints and primary harm brought about by different rheumatic sicknesses. PDUS is more exact than clinical assessment in deciding irritation in joints, ligament sheaths, ligaments, and entheses in patients with constant fiery joint inflammation and grant observing of illness activity. The factors analysed by US can expand the possibilities of early identification of RA despite the fact that the Cyclic citrullinated Peptide-CCP [4] and Rheumatoid Variable RF are negative. The ultrasound is central in the demonstration of the rheumatologist to stop future basic mishap, giving more accommodating to the patient by quick, boundless and safer checking without elucidation. The following papers have been included in the Table 1 [1–23, 30–33].

Table 1. Literature Review of Power Doppler Ultrasound Imaging.

S.no	Year of Publication	Authors	Title of the paper	Methods Used
1.	2021	Ahmed Okasha, et al.	Role of Ultrasonography and power Doppler of Wrist and Hand Joints in Diagnosis of Early Symptomatic Cases of Rheumatoid Arthritis.	Patients examined by GE LOGIQ P5 ultrasound machine.
2.	2021	ReemHamdy A. Mohammed, et al.	Hand and Wrist Rheumatoid Arthritis	<ul style="list-style-type: none"> • The etiologic factors in rheumatoid arthritis have been reviewed. • Disease features in rheumatoid arthritis reviewed. • The management of rheumatoid arthritis Outlined. • Latest updates in patient handling Outlined, evaluation and treatment discussed.
3.	2020	Neil Cronin	Automated Analysis Of Musculoskeletal Ultrasound Images Using Deep Learning.	(i)U-Net Model (ii)Neural Network Training.

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Table 1. (continued)

S.no	Year of Publication	Authors	Title of the paper	Methods Used
4.	2020	Khalid Almutairi, et al.	The global prevalence of rheumatoid arthritis: a meta-analysis based on a systematic review;	Inclusion and exclusion criteria
5.	2019	Eman M. El-Serougy, et al.	Power Doppler ultrasound in the evaluation of hand joints in rheumatoid arthritis patients in clinical remission: Association with composite index scores and functional status	(i)The modified health assessment questionnaire (MHAQ); (ii)Ultrasonographic assessment
6.	2019	Motoshi Fujimori, et al.	Quantitative power Doppler signal assessment in the subchondral bone region of the metacarpophalangeal joint is an effective predictor of radiographic progression in the hand of rheumatoid arthritis: a pilot study	Quantitative subchondral bone signal assessment.
7.	2018	Facundo Vergara, et al.	The Value of Power Doppler Ultrasound in Patients with Rheumatoid Arthritis in Clinical Remission: Reclassifying Disease Activity?	(i)Clinical Examination (ii)Ultrasound Evaluation (iii)Statistical Analysis.
8.	2018	Marina Carotti, et al.	Clinical utility of eco-colour-power Doppler ultrasonography and contrast enhanced magnetic resonance imaging for interpretation and quantification of joint synovitis: a review	Different semi-quantitative systems have been proposed for scoring intra-articular power Doppler signals.
9.	2018	Aline Defaveri do Prado, et al.	Ultrasound and its clinical use in rheumatoid arthritis: where do we stand?	MSUS clinical application as compared to classical activity parameters.

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Table 1. (continued)

S.no	Year of Publication	Authors	Title of the paper	Methods Used
10.	2017	Kaoru Takase-Minegishi, et al.	Diagnostic test accuracy of ultrasound for synovitis in rheumatoid arthritis: systematic review and meta-analysis.	DerSimonian Laird random effects model
11.	2016	U.Snehalatha, et al.	Ultrasound Colour Doppler Image Segmentation and Feature Extraction in MCP and Wrist Region in Evaluation of Rheumatoid Arthritis	Ultrasound image segmentation and Feature Extraction using HAQ.
12.	2016	Dee Sreerangaiah, et al.	Quantitative power Doppler ultrasound measures of peripheral joint synovitis in poor prognosis early rheumatoid arthritis predict radiographic progression	(i)Imaging assessments (ii)Statistical methodology.
13.	2015	ShalooBhasin, et al.	The Role of Power Doppler Ultrasonography as Disease Activity Marker in Rheumatoid Arthritis	Treating to Target to Achieve Disease Remission is the Goal in RA.
14.	2015	MihraS.Taljanovic, MD, PhD, et al.	High-Resolution US of Rheumatologic Diseases.	Eular Criteria.
15.	2014	E. Naredo, et al.	Doppler techniques	Applications of Doppler ultrasound in rheumatology
16.	2014	ArnoldasCeponis, et al.	Utility of the Ultrasound Examination of the Hand and Wrist Joints in the Management of Established Rheumatoid Arthritis.	Fifty-one RA patients were evaluated using: (i)Clinical disease activity measures and (ii)gray-scale and (iii) power Doppler (PD) US.

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Table 1. (continued)

S.no	Year of Publication	Authors	Title of the paper	Methods Used
17.	2014	Gargy Mondal, et al.	Comparative Study of Radiological Changes in Hands and Feet in Patients Suffering from Early Rheumatoid Arthritis by Power Doppler Ultrasound and Direct Digital Radiography.	Inclusion Criteria Exclusion Criteria
18.	2012	Francesco Porta, et al.	The role of Doppler ultrasound in rheumatic diseases	Comparison of Doppler Ultrasound modalities.
19.	2011	J A Mendonca, et al.	Wrist ultrasound analysis of patients with early rheumatoid arthritis	Gray scale (GS) and powerDoppler (PD) ultrasound were applied to patients with early RA and correlated with clinical, laboratory and radiological data.
20.	2011	Johannes Strunk, et al.	Doppler ultrasonography for assessing rheumatoid arthritis	Musculoskeletal Ultrasonography in Rheumatology.
21.	2010	Nevbahar Akcar, et al.	Value of Power Doppler and Gray-Scale US in the Diagnosis of Carpal Tunnel Syndrome: Contribution of Cross-Sectional Area just before the Tunnel Inlet as Compared with the Cross-Sectional Area at the Tunnel	Klauser and Shio's method.
22.	2008	Lene Terslev, et al.	Diagnostic Sensitivity and Specificity of Doppler Ultrasound in Rheumatoid Arthritis	Mean Health Assessment Questionnaire(HAQ), Image Analysis, Statistical Analysis.
23.	2008	Annamaria Iagnocco, et al.	Power Doppler ultrasound monitoring of response to anti-tumour necrosis factor alpha treatment in patients with rheumatoid arthritis	Clinical and Laboratory assessments were performed.

The applications and effectiveness of Power Doppler Ultrasound in early diagnosis of Rheumatoid Arthritis and the different methods used in the various papers [1–23, 30–33] has been discussed in the above table.

2.2 Segmentation Techniques

Segmentation is the process dividing an image into regions with similar properties such as gray level, color, texture, brightness, and contrast. The role of segmentation is to subdivide the objects in an image; in case of medical image segmentation the aim is to: Study anatomical structure. We study the different Segmentation Techniques in the following Table 2. The following papers have been mentioned in the Table 2: [29–96].

Table 2. Segmentation Techniques

S.no	Author	Year of Publication	Title of the paper	Segmentation Techniques
1	Vivian Bass, Julieta Mateos, et al.	2021	Ultrasound image segmentation methods: A review	Thresholding, Clustering, Active Contours, Neural Networks(NN)
2	Nelson Martins	2020	Joint Capsule Segmentation in Ultrasound Images of the Metacarpophalangeal Joint using Convolutional Neural Networks	Data Augmentation-U-Net model
3	Deeparani M, et al.	2018	A Survey on Ultrasound Image Segmentation Algorithm for Detection of Female Pelvic Masses	Various Ultrasound image segmentation Algorithms
4	SimraZeibaMumtaz, et al.	2018	A Brief Review On Various Image Segmentation Techniques For Detection Of Arthritis A Survey Report	Techniques Involved in Detection of Arthritis Through MRI Images
5	Yaozhong Luo, et al.	2017	A Novel Segmentation Approach Combining Region- and Edge-Based Information for Ultrasound Images	Multi-objectively optimized robust graph-based (MOORGB) segmentation method, which utilizes PSO algorithm

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Table 2. (continued)

S.no	Author	Year of Publication	Title of the paper	Segmentation Techniques
6	Kristen M. Meiburger, et al.	2017	Automated localization and segmentation techniques for B-mode ultrasound images: A review	<ul style="list-style-type: none"> • Local pixel statistics, • Active contours, • Edge-tracking, • Dynamic programming, and • Data mining
7	Sylvia Rueda	2015	Feature-based fuzzy connectedness segmentation of ultrasound images with an object completion step	Segmentation in the US in view of a fuzzy association model and Segmentation Framework
8	Tatiana D. C. A. Silva	2015	Image Segmentation Algorithms and their use on Doppler Images	Segmentation Algorithms: Algorithms based on Thresholding, Edge based Segmentations, Region based Segmentation, Clustering Algorithms, Hybrid Algorithms
9	Mei Yeen Choong, et al.	2011	Variational Level Set Algorithm in Image Segmentation for Foetus Ultrasound Imaging System	<ul style="list-style-type: none"> • Traditional Level Set Method • Medical Image Segmentation using Variational Level Set Method Foetal length Measurement
10	Kalpana Saini, et al.	2010	Ultrasound Imaging and Image Segmentation in the area of Ultrasound: A Review	<ul style="list-style-type: none"> • Edge based approaches • Region based approaches

3 Results and Discussion

In this paper we have discussed the effectiveness and accuracy of power Doppler ultrasound through the various methods in the Table-1. The various Segmentation techniques have been discussed in Table-2. Edge-based segmentation is one of the most popular

implementations of segmentation in image processing. It focuses on identifying the edges of different objects in an image. Thus among the segmentation techniques Edge-based segmentation helps in identifying the region of interest with more accuracy and precision.

4 Conclusion

This survey covers 10 years of examination into the conclusion of rheumatoid joint pain utilizing Doppler ultrasound and its division procedure. Grayscale ultrasound assists with imagining just hypertrophy/radiation of the joint, while PDUS analyse expanded blood stream in miniature vessels in bursitis by noticing the development of veins. PDUS is more exact than ordinary US. The job of PDUS in RA is that the determination tells the truth, significant, delicate to change, and solid. In examination, PDUS enjoys the accompanying upper hands over other imaging strategies: This implies higher stream responsiveness, better edge identification and stream progression. PDUS shows improved hardware, which shouldn't be visible ahead of the differentiation specialist, without modifying the addition and in this way without forfeiting awareness. Power Doppler shows blood stream in veins utilizing high recurrence sound waves, dissimilar to ordinary sound waves which can create pictures yet not blood stream. PDUS upholds early finding of rheumatoid joint inflammation in the wrist and different joints, prompting reduction and early mending. Hence, PDUS is superior to customary ultrasound as well as other imaging modalities and furthermore helps in early recognition of RA in the joints before the beginning of bone disintegration or different side effects. This helps prevent an increase in structural damage caused by RA. Prevents disease progression in RA patients. As a result, PDUS is more sensitive, accurate and reliable, distinguishing it from other ultrasound and other imaging modalities.

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