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The Application of Interdisciplinary Integrated Teaching in Rheumatoid Arthritis (RA) Medical Education

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Abstract: Interdisciplinary Integrated Teaching is based on constructivist learning theory, systems theory, and collaborative learning theory, emphasising the comprehensive nature of knowledge and its contextual application. Constructivism holds that learning is a process of constructing personal cognition through the integration of knowledge from different fields, while systems theory emphasises that the diagnosis and treatment of complex diseases such as RA require a multidisciplinary collaborative perspective. Collaborative learning theory supports the cultivation of students' comprehensive abilities and problem-solving skills through teamwork. RA is a chronic, systemic autoimmune disease involving multiple organ systems and complex management strategies. Interdisciplinary integrated teaching integrates disciplines such as rheumatology and immunology, imaging, and pharmacy to help students understand the pathophysiological mechanisms, diagnostic criteria, treatment protocols, and patient management of RA, thereby enhancing their ability to address complex diseases.

Keywords: Interdisciplinary integrated teaching; Rheumatoid arthritis; Medical education

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1. Introduction

Holistic, student-centred, interdisciplinary collaboration, and contextual learning are the core principles of modern educational reform. These concepts not only enhance students' learning outcomes and overall literacy but also promote their development in future careers. By integrating knowledge from different disciplines, adopting student-centred teaching methods, and simulating multidisciplinary team collaboration, educators can better cultivate students' comprehensive abilities and innovative capabilities. These concepts are not only significant in theory but have also been widely applied and verified in practice.

2. Core principles of interdisciplinary integrated teaching and its advantages in medical education

First, the emphasis on holistic learning involves integrating knowledge across disciplines to avoid fragmentation between subjects. By integrating knowledge from different disciplines, students can gain a more comprehensive understanding of complex issues, thereby enhancing their problem-solving abilities. For example, in medical education, integrating biomedical and clinical science course design can effectively reduce content repetition and help students better understand the clinical significance of the knowledge they learn. Additionally, interdisciplinary course design can promote knowledge transfer and application across disciplines, thereby enhancing students' overall literacy [1].

Secondly, student-centred teaching methods emphasise problem-based learning to stimulate students' proactive exploration. Research shows that student-centred teaching methods can significantly improve students' learning outcomes. For example, in science education, adopting student-centred teaching methods can enhance students' understanding of scientific concepts and strengthen their self-efficacy [2]. Additionally, problem-based learning can encourage students to apply their knowledge in real-world contexts, thereby improving their ability to solve practical problems [3].

Thirdly, interdisciplinary collaboration simulates the multidisciplinary team collaboration model in clinical environments, effectively improving students' teamwork and interdisciplinary communication skills. In medical education, interdisciplinary simulation training significantly enhances students' teamwork and communication abilities [4]. Furthermore, interdisciplinary collaboration promotes knowledge exchange and sharing across disciplines, thereby enhancing students' innovation capabilities and ability to address complex problems [5,6].

Fourth, contextualised learning: centring on real-life cases to enhance the clinical applicability of knowledge is a crucial concept in modern medical education. By placing learning content in real clinical contexts, students can not only better understand and apply what they have learned but also improve their clinical decision-making abilities and professional competence. Contextualised learning simulates real clinical environments, allowing students to practise and make mistakes in a safe environment, thereby improving their clinical skills and decision-making abilities. Case-based learning provides real clinical scenarios, enabling students to learn and apply knowledge in a controlled environment. This approach emphasises the concept of ontological fidelity, which involves considering what information is real in case design and what aspects of reality we aim to simulate through the case [7]. Research indicates that the disconnect phenomenon encountered by students in clinical settings, where an element of patient interaction contradicts existing reference frameworks, prompts students to reassess and revise their assumptions, thereby enhancing their judgment capabilities [8].

Interdisciplinary integrated teaching plays a significant role in medical education, particularly in understanding the pathology, diagnosis, and treatment of complex diseases such as rheumatoid arthritis (RA). By integrating knowledge from different disciplines, students can gain a comprehensive understanding of the complexity of diseases from a multidisciplinary perspective and develop systematic clinical thinking skills.

Firstly, interdisciplinary integrated teaching helps students better understand the pathological mechanisms and treatment methods of RA. By combining basic science with clinical science, students can gain a deeper understanding of the biological basis of diseases and their clinical manifestations. For example, a study found that integrating biomedical and clinical science education significantly improved students' understanding of diseases and diagnostic abilities. Additionally, another study demonstrated that through an interdisciplinary simulation practice system, students could utilise open datasets for case analysis, thereby validating the

effectiveness of case simulation analysis in interdisciplinary scenarios [9]. Secondly, interdisciplinary teaching models such as multidisciplinary diagnosis and treatment (MDT) combined with case-based learning (CBL) have proven highly effective in cultivating students' clinical thinking. Research shows that students using the MDT combined with the CBL teaching model scored significantly higher than those using traditional teaching models in terms of foundational theoretical knowledge, clinical skills, and case analysis abilities [10]. This teaching model not only enhances students' self-directed learning abilities but also strengthens their capabilities in clinical diagnosis and treatment thinking.

Additionally, interdisciplinary teaching promotes students' systematic thinking abilities in complex case analysis. By introducing real patient cases and simulated patient videos, students can better apply foundational scientific knowledge to clinical contexts, thereby improving their clinical decision-making abilities [11,12], This teaching method emphasises the connection between foundational science and clinical practice, enabling students to apply their knowledge more effectively in real clinical environments. In summary, interdisciplinary integrated teaching in medical education not only helps students comprehensively understand the complexity of diseases but also cultivates their clinical thinking abilities. This teaching method provides students with a platform for systematically analysing complex cases by integrating knowledge from different disciplines, thereby enhancing their clinical practice abilities and professional competence [13,14]. This teaching model is worthy of further promotion and application in medical education.

By simulating a multidisciplinary team (MDT) environment, students can experience and practice interdisciplinary collaboration in real clinical settings, thereby enhancing their teamwork skills in actual work scenarios. Research indicates that interprofessional education (IPE) effectively fosters students' collaborative practice abilities before they enter the healthcare industry [15]. This educational model not only helps students understand public health concepts but also strengthens their willingness to collaborate with community resources [15].

In interprofessional education, simulation-based teaching is an important tool. By simulating real clinical scenarios, students can practice and improve their communication and teamwork skills in a safe environment [16]. For example, in one study, simulation-based teaching significantly improved participants' leadership communication skills and the effectiveness of teamwork [16]. Additionally, interprofessional teaching rotations have been shown to significantly enhance medical students' clinical problem-solving abilities and interprofessional collaboration skills [17].

The successful implementation of interdisciplinary education requires carefully designed curricula and assessment mechanisms. Research indicates that designing and implementing competency-based interdisciplinary team education strategies is key to enhancing students' teamwork abilities [18]. By conducting comprehensive interdisciplinary needs analyses and establishing transferable, evidence-based competencies, educational institutions can more effectively integrate teamwork education and training into undergraduate medical training [18]. Furthermore, the introduction of interdisciplinary teaching units has been shown to promote learning and collaboration across disciplines, thereby improving workplace culture and educational quality [19].

Interdisciplinary education should not be limited to medical and nursing disciplines but should also include non-clinical disciplines such as public health and informatics to form patient-centred multidisciplinary teams [4]. By incorporating students from these disciplines into traditional clinical simulations, communication and teamwork skills can be significantly enhanced [4]. This multidisciplinary integration not only allows students to observe and learn interdisciplinary teamwork during their studies but also provides them with opportunities to learn from faculty role models [4].

3. The application of multidisciplinary integration in rheumatoid arthritis (RA)

Rheumatoid arthritis (RA) is a chronic, systemic autoimmune disease that not only affects the joints but also involves multi-organ system lesions and complex management strategies. The pathophysiological mechanisms of RA are complex, involving multiple immune cells and inflammatory factors. Research indicates that the pathogenesis of RA can be divided into three stages: first, environmental factors activate the innate immune system, which then induces an adaptive immune response, leading to the production of autoantibodies; subsequently, joint-specific inflammatory responses occur, ultimately progressing to chronic inflammation, resulting in tissue destruction and remodelling [20,21]. The pathophysiology of RA is not limited to the joints but also involves systemic immune dysregulation. Research indicates that systemic autoimmunity in RA patients may be triggered in mucosal organs, such as the lungs, long before joint inflammation occurs [21]. Additionally, the association between RA and cardiovascular complications has been extensively studied, with inflammation considered the key process linking RA to cardiovascular disease [22]. This suggests that RA management requires interdisciplinary integration across fields such as rheumatology, cardiology, and imaging to optimize treatment strategies for patients. To better understand the pathophysiology of RA and develop more effective treatment strategies, interdisciplinary integrated education is particularly important. By integrating rheumatology, immunology, imaging, and pharmacy, students can gain a more comprehensive understanding of the complex pathophysiology of RA. This multidisciplinary collaboration not only aids in the early diagnosis and management of the disease but also improves patients' quality of life and treatment outcomes [23,24].

3.1. Limitations of current RA teaching methods

Current RA teaching primarily focuses on a single discipline and has the following limitations: fragmented knowledge, lack of a multidisciplinary perspective, insufficient practical experience, a theory-centric approach, weak patient-centred philosophy, and neglect of the role of psychology and rehabilitation in RA patient management. This single-discipline teaching model leads to fragmented knowledge, making it difficult for students to integrate knowledge from different disciplines and apply it to clinical practice. Research indicates that multidisciplinary collaboration is essential in the medical care of chronic disease patients, particularly in rheumatology, where interdisciplinary work is crucial for addressing the complex physical and psychosocial aspects of chronic diseases [25].

The roles of psychology and rehabilitation are often overlooked in the management of RA patients. Psychological therapies, such as cognitive behavioural therapy (CBT), have been proven effective in managing pain in RA patients, particularly when intervention occurs early in the disease course [26]. However, current RA education places insufficient emphasis on psychological interventions, leaving students ill-equipped to apply this knowledge effectively in clinical practice. Additionally, patient education needs to shift from mere information dissemination to more interactive and patient-centred approaches to enhance patients' self-management capabilities and treatment adherence [27].

The multidisciplinary team (MDT) teaching model has demonstrated significant effectiveness in enhancing students' clinical skills and the application of theoretical knowledge. For example, in respiratory rehabilitation nursing education, the integration of competency-based education (CBE) and the MDT teaching model significantly improved students' theoretical exam scores, practical skills, and teaching satisfaction [28]. The successful application of this model demonstrates that a multidisciplinary perspective and practice-oriented teaching methods can effectively address the current deficiencies in RA education, such as insufficient practical training and a lack of multidisciplinary perspectives.

Furthermore, the application of patient-centred care principles in RA management also requires further strengthening. Research indicates that patient-reported outcomes (PROs) can improve doctor-patient communication, decision-making, and patient satisfaction in RA nursing [29]. However, the current RA teaching still lacks sufficient emphasis on the patient-centred philosophy, leading to students struggling to comprehensively consider patients' psychological and social factors in clinical practice. Therefore, future RA teaching should place greater emphasis on fostering multidisciplinary collaboration and the patient-centred philosophy to enhance students' comprehensive abilities and clinical practice capabilities.

4. The role and interrelationship of various disciplines in RA diagnosis, treatment, and management

The following are the specific roles of each discipline in RA diagnosis and treatment and their interrelationships.

4.1. Internal medicine (Rheumatology and Immunology)

In the diagnosis, assessment of disease activity, and development of treatment plans for rheumatoid arthritis (RA), understanding the immunopathological mechanisms and focusing on the systemic effects of the disease are of critical importance. Research indicates that the pathophysiological mechanisms of RA primarily involve the interaction of T cells, B cells, and various cytokines, which collectively lead to synovial inflammation and joint damage [30]. Furthermore, the systemic effects of RA are not limited to the joints but may also involve the cardiovascular system, lungs, and other organs [31].

In the diagnosis and assessment of disease activity in RA, imaging techniques such as ultrasound and PET/CT are widely used to evaluate joint damage and inflammatory activity. Studies have shown that ultrasound is more reliable than traditional inflammatory parameters in assessing disease activity in RA patients, particularly in those receiving biologic therapy [32,33]. Additionally, PET/CT can be used to predict the extent of damage to large joints and can be combined with disease activity scores (such as DAS28) to provide a more comprehensive assessment [34].

Pharmacy collaboration also plays an important role in optimising RA treatment. By collaborating with pharmacy teams, medication use can be better managed, treatment responses monitored, and drug doses adjusted as needed [35]. Furthermore, radiology provides important support in confirming the extent of joint damage, helping clinicians more accurately assess disease progression and treatment efficacy [36].

4.2. The role of radiology in rheumatoid arthritis

The application of imaging techniques in rheumatoid arthritis (RA) holds significant clinical importance, particularly in assessing joint inflammation, bone erosion, and soft tissue damage. Through imaging technologies such as X-rays, ultrasound, and MRI, objective imaging evidence can be provided to monitor the progression of RA and support diagnostic decisions in rheumatology and immunology.

Firstly, traditional X-ray examinations still play a crucial role in the diagnosis of RA. X-rays can quickly provide an overall overview of symptomatic joints, helping to narrow down the differential diagnosis and assess disease progression. Radiological features of RA include soft tissue swelling, periarticular osteoporosis, erosion, loss of joint space, and bone resorption and typical joint subluxation or deformity, such as ulnar deviation, in the late stages of the disease [37,38]. However, X-rays have low sensitivity in detecting early inflammation, so MRI and ultrasound are considered more effective tools for early diagnosis [39,40].

Ultrasound also plays an important role in the management of RA. Studies have shown that ultrasound

has high sensitivity and specificity in detecting joint inflammation and bone erosion, particularly when MRI is unavailable or unaffordable, making it a valuable tool [41,42]. Additionally, ultrasound can assess the severity of synovitis and tendonitis using semi-quantitative scoring systems, which is crucial for monitoring treatment responses [43,44].

MRI has unique advantages in the early diagnosis and disease progression monitoring of RA. MRI can detect synovitis and bone marrow oedema that are not clinically apparent, and these subclinical inflammations are closely associated with radiological progression [45,46]. Furthermore, MRI can assess the progression and repair of bone erosion. Studies have shown that MRI has significantly higher sensitivity than X-rays in detecting bone erosion and repair [47,48]. By combining multi-modal imaging techniques, such as high-resolution peripheral quantitative computed tomography (HR-pQCT) and MRI, joint tissue characteristics can be better characterised, aiding in the understanding of the development and pathophysiology of RA-related bone erosion [49,50].

In summary, imaging techniques are indispensable in the diagnosis and management of RA. The combined use of X-rays, ultrasound, and MRI provides rheumatology and immunology departments with more comprehensive diagnostic evidence, helping to develop personalised treatment plans and improve patient outcomes [51,52]. This multi-level imaging assessment not only aids in early diagnosis but also plays a critical role in monitoring disease progression and treatment response [53,54].

4.3. Interdisciplinary collaboration with the laboratory department

The role of the laboratory department in rheumatology and immunology is crucial, particularly in the detection of rheumatoid factor (RF), anti-cyclic citrullinated peptide antibodies (ACPA), and inflammatory markers. These tests not only aid in disease diagnosis but also monitor drug side effects and treatment efficacy. According to relevant studies, biologics play an important role in the treatment of rheumatic diseases, but their immunogenicity may lead to the production of anti-drug antibodies, thereby affecting drug efficacy [55]. Therefore, the laboratory plays a key role in the rational use and management of biologics.

ACPA and RF are important serological markers in the diagnosis of rheumatoid arthritis (RA). Studies have shown that combining the likelihood ratio (LR) of RF and ACPA with pre-test probability can improve the diagnostic accuracy of RA [56]. Additionally, body mass index (BMI) significantly influences cytokine patterns in RA patients, and adjusting for BMI can more accurately predict ACPA status and joint inflammation activity [57]. These studies highlight the importance of multi-marker assessment in understanding disease processes.

Laboratory testing also plays a crucial role in monitoring disease activity and treatment efficacy. Studies have found that serum calcitonin gene-related peptide (CGRP) has a stronger association with inflammation and disease activity in ACPA-positive RA patients, suggesting that CGRP may have a specific role in such patients [58]. Additionally, anti-CarP antibodies are considered promising biomarkers for predicting joint damage and disease activity in RA patients [59]. The application of these biomarkers not only aids in early disease diagnosis but also guides the development of personalized treatment strategies.

4.4. The application of rehabilitation medicine in rheumatoid arthritis

The Department of Rehabilitation plays a crucial role in modern medicine, particularly in the design of physical therapy and functional exercise programmes. The unique perspective of the Department of Rehabilitation lies in its focus on patient functional recovery and long-term management, which not only involves the development of post-operative rehabilitation plans but also collaboration with the Nursing Department to ensure improvements in patients' activities of daily living.

Firstly, the role of the Rehabilitation Department in post-operative rehabilitation has been widely supported by research. For example, in patients with hip fractures, comprehensive rehabilitation is considered key to promoting physical functional recovery and reducing complications [60]. This multidisciplinary rehabilitation approach emphasises the importance of physical and occupational therapy, helping patients achieve optimal functional status during the post-operative recovery process. Additionally, studies have shown that the continuous care model yields better outcomes in patients following hip replacement surgery, not only improving hip function but also enhancing quality of life and reducing anxiety and depression [61].

Secondly, collaboration between the Rehabilitation Department and the Nursing Department also plays a significant role in promoting patients' activities of daily living. Research indicates that comprehensive rehabilitation care significantly improves neurological functional recovery and activities of daily living in acute stroke patients [62]. This care model enhances patients' neurological functional recovery by promoting the improvement of vascular stenosis and the establishment of collateral circulation. Furthermore, comprehensive rehabilitation care interventions have also shown significant effects in patients with intracerebral haemorrhage, not only improving postoperative neurological and limb function but also alleviating patients' adverse psychological states and enhancing postoperative quality of life [63].

Finally, the rehabilitation department has also made significant progress in the use of emerging technologies. For example, virtual reality technology has been proven to effectively improve upper limb motor function and manual dexterity in stroke patients [64]. Additionally, the combination of constraint-induced movement therapy and botulinum toxin use has shown potential in improving motor function and activities of daily living in patients with post-stroke spasticity [65]. The application of these technologies not only enriches the treatment options available to the Rehabilitation Department but also provides patients with more rehabilitation choices.

As such, the Rehabilitation Department plays an indispensable role in designing physical therapy and functional exercise programmes. Its unique perspective and multidisciplinary collaboration model provide strong support for patients' functional recovery and long-term management. By continuously introducing new technologies and optimising care models, the Rehabilitation Department will continue to play a crucial role in enhancing patients' quality of life and functional recovery.

4.5. Application of other disciplines in rheumatoid arthritis

In the field of orthopedics', addressing severe joint deformities or cases requiring surgical intervention (such as joint replacement) is one of its core tasks. Joint replacement surgery not only effectively alleviates pain but also significantly improves patients' quality of life. Studies have shown that patients with rheumatoid arthritis (RA) who undergo hip and knee joint replacement surgery have lower rates of complications and mortality during hospitalization compared to non-RA patients, which may be attributed to appropriate preoperative and perioperative management of RA patients [66] Additionally, for joint replacement surgery in RA patients, optimization the patient's condition preoperatively, rational use of medications, and multidisciplinary team collaboration are key to success [67,68].

In terms of pharmacy, the selection of medications, dose adjustments, and management of side effects for RA are important responsibilities of pharmacy. Studies have shown that early use of disease-modifying antirheumatic drugs (DMARDs) can delay the need for joint replacement surgery [69]. However, the use of DMARDs and biologics may increase the risk of postoperative infection, so these medications should be discontinued prior to surgery based on their half-life and adjusted under the guidance of a rheumatologist [70,71]

Additionally, for elderly RA patients, drug selection requires particular caution to balance efficacy with potential severe side effects, such as neutropenia [72].

Nursing plays a crucial role in the management of RA patients. Nursing staff not only provide patient education but also play an active role in post-operative rehabilitation. Studies have shown that specialised nutritional management combined with professional nursing care can significantly improve the nutritional status, immune function, and wound healing of patients after joint replacement surgery [73]. Furthermore, nursing staff can significantly enhance patients' health and rehabilitation experiences throughout their joint replacement journey by sharing information, providing support, and coordinating care [74]. In modern nursing, the application of Internet of Things (IoT) technology is also continuously improving nursing efficiency and patient satisfaction [75]. Psychology plays a significant role in managing anxiety, depression, and the psychological burden of chronic illness in patients with rheumatoid arthritis (RA). Research indicates that mental health issues such as anxiety and depression in RA patients significantly impact disease management and quality of life [76]. The prevalence of depression among RA patients is twice that of the general population, and there is a bidirectional relationship between these mental health issues and RA. Chronic inflammation weakens the physiological response to stress, leading to depression, which in turn hurts the long-term prognosis of RA [76].

Additionally, psychological stress plays a significant role in the onset and progression of RA. Studies have found that RA patients experience significantly more life events prior to symptom onset compared to control groups, particularly in female patients, where cumulative stress is associated with RA onset in a dose-dependent manner [77]. This suggests that psychological stress may not only be a trigger for RA but may also exacerbate its severity. Therefore, managing psychological stress in RA patients is crucial for improving disease outcomes.

Psychological interventions have demonstrated positive effects in the management of RA patients. Group cognitive behavioural therapy (CBT) has been proven to effectively reduce anxiety and depression symptoms and improve functional impairment [78]. In RA patients, psychological intervention measures such as CBT can help patients better cope with the psychological burden of the disease and improve their quality of life [76]. Additionally, research indicates that RA patients' coping strategies are closely related to their perceived disease severity, with emotional distress mediating this relationship [79]. Therefore, adjusting coping strategies and reducing emotional distress can serve as important means to improve the mental health of RA patients.

5. The importance of cultivating team collaboration skills and methods of integration

5.1. Importance

(1) Clinical Practice Requirements: RA management requires MDT collaboration, and students must possess interdisciplinary communication and collaboration skills.

(2) Improved Patient Outcomes: Multidisciplinary collaboration can optimise the comprehensive management of RA patients and reduce the risk of complications.

(3) Career Preparation: Cultivating team collaboration skills helps students adapt to future clinical work environments.

5.2. Integration methods

(1) MDT Simulation-Based Teaching: Students are divided into groups to assume different disciplinary roles and engage in diagnostic and treatment plan discussions based on RA cases.

(2) Interdisciplinary Workshops: Organise joint lectures by faculty members from rheumatology, imaging,

nursing, and other disciplines to guide students in completing interdisciplinary tasks.

(3) Reflective Learning: Require students to write reflective reports after team tasks, analysing challenges encountered and strategies for improvement.

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Disclosure statement

The authors declare no conflict of interest

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