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Review article

Non-Steroidal Anti-Inflammatory Drugs for the Control of Autoimmune Diseases: A Short Review of Mechanisms, Clinical Applications, and Emerging Perspectives

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Abstract

Non-steroidal anti-inflammatory drugs (NSAIDs) remain among the most widely prescribed medications worldwide for the management of pain and inflammation in autoimmune rheumatic diseases. This comprehensive review examines the pharmacological mechanisms, clinical applications, safety profiles, and evolving role of NSAIDs in the treatment of autoimmune diseases, with particular focus on rheumatoid arthritis (RA), psoriatic arthritis (PsA), axial spondyloarthritis (axSpA), and juvenile idiopathic arthritis (JIA). NSAIDs exert their primary therapeutic effects through inhibition of cyclooxygenase (COX) enzymes, thereby reducing prostaglandin synthesis. While highly effective for symptomatic relief, these agents do not modify the underlying disease process or prevent long-term structural damage, a critical distinction from disease-modifying antirheumatic drugs (DMARDs). The review synthesizes evidence from recent clinical trials, meta-analyses, and clinical practice guidelines, demonstrating that NSAIDs serve as first-line therapy for rapid symptom control, particularly as bridging therapy while DMARDs take effect. However, their use is constrained by significant safety concerns, including gastrointestinal toxicity, cardiovascular risks, and renal impairment. Selective COX-2 inhibitors offer improved gastrointestinal safety but are associated with increased cardiovascular events, with naproxen appearing least harmful among traditional NSAIDs. Emerging trends include the development of novel formulations such as topical NSAIDs, nitric oxide-donating hybrids, dual-acting anti-inflammatory agents, and targeted drug delivery systems. Despite the advent of biologic and targeted synthetic DMARDs, NSAIDs continue to occupy an important adjunctive role in autoimmune disease management when used judiciously with appropriate risk stratification. This review provides clinicians with evidence-based guidance for optimizing NSAID therapy while minimizing adverse effects, and highlights future directions for safer, more effective anti-inflammatory agents.

Keywords:
Non-steroidal anti-inflammatory drugs, autoimmune diseases, rheumatoid arthritis, spondyloarthritis, cyclooxygenase inhibitors, drug safety, cardiovascular risk, gastrointestinal toxicity, disease-modifying antirheumatic drugs, topical NSAIDs, nitric oxide-donating NSAIDs.

Introduction

Autoimmune diseases represent a diverse group of disorders characterized by dysregulation of the immune system, leading to chronic inflammation and tissue damage. Among the most prevalent autoimmune conditions affecting the musculoskeletal system are rheumatoid arthritis (RA), psoriatic arthritis (PsA), axial spondyloarthritis (axSpA), and juvenile idiopathic arthritis (JIA). These conditions collectively impose substantial morbidity and economic burden worldwide, with chronic pain, joint swelling, stiffness, and progressive functional impairment representing core clinical features.

The management of autoimmune rheumatic diseases has evolved dramatically over the past several decades, with the introduction of biologic and targeted synthetic disease-modifying antirheumatic drugs (DMARDs) fundamentally altering treatment paradigms (Gossec et al., 2020; Singh et al., 2016). Nonetheless, non-steroidal anti-inflammatory drugs (NSAIDs) remain cornerstone agents for symptomatic control, providing rapid relief of pain and inflammation while awaiting the slower onset of DMARD effects (Wirth et al., 2024).

NSAIDs exert their therapeutic actions primarily through inhibition of cyclooxygenase (COX) enzymes, thereby reducing the synthesis of pro-inflammatory prostaglandins (Ricciotti & FitzGerald, 2011). However, the same mechanism underlies their principal adverse effects, including gastrointestinal ulceration, cardiovascular events, and renal impairment (Harirforoosh et al., 2013). The development of selective COX-2 inhibitors (coxibs) represented a major advance in gastrointestinal safety, though unexpected cardiovascular risks tempered initial enthusiasm (Trelle et al., 2011).

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This review aims to comprehensively examine the current evidence regarding NSAID use in autoimmune diseases, synthesizing findings from recent clinical trials, meta-analyses, and practice guidelines. We discuss pharmacological mechanisms, clinical applications across major autoimmune conditions, safety profiles, limitations, and emerging trends in NSAID development. By critically evaluating the risks and benefits, we provide a framework for rational prescribing that maximizes therapeutic benefits while minimizing adverse effects.

1. Pharmacological Mechanisms of Action

1.1 COX Inhibition and Prostaglandin Synthesis

The primary mechanism of action of NSAIDs involves inhibition of cyclooxygenase (COX) enzymes, which catalyze the conversion of arachidonic acid to prostaglandin H_2 (PGH_2), the precursor for various prostaglandins and thromboxanes (Vane & Botting, 1998). Prostaglandins are key mediators of inflammation, pain, and fever, and also play essential physiological roles in gastric mucosal protection, renal function, and platelet homeostasis.

Two COX isoforms exist: COX-1 is constitutively expressed in most tissues and is responsible for the production of prostaglandins that maintain normal physiological functions, including gastric cytoprotection and renal perfusion (Warner & Mitchell, 2004). COX-2 is primarily induced at sites of inflammation in response to cytokines, growth factors, and other inflammatory stimuli, driving the production of pro-inflammatory prostaglandins (Simon et al., 1998).

Traditional non-selective NSAIDs inhibit both COX-1 and COX-2 to varying degrees. The therapeutic anti-inflammatory and analgesic effects derive principally from COX-2 inhibition, while the gastrointestinal and renal adverse effects are largely attributable to COX-1 inhibition (Grosser et al., 2017).

1.2 COX Selectivity

Selective COX-2 inhibitors (coxibs) were developed with the aim of preserving anti-inflammatory efficacy while reducing gastrointestinal toxicity (FitzGerald & Patrono, 2001). By sparing COX-1, these agents maintain gastric mucosal protection but, as discussed below, have been associated with unexpected cardiovascular risks. Commonly used coxibs include celecoxib, etoricoxib, and lumiracoxib.

The degree of COX selectivity varies among NSAIDs. Celecoxib is a moderately selective COX-2 inhibitor, while rofecoxib (withdrawn from the market) and etoricoxib are highly selective (Warner et al., 1999). Traditional NSAIDs exhibit variable COX-1/COX-2 selectivity ratios; for example, ketorolac and indomethacin are relatively non-selective, while meloxicam and nimesulide show preferential COX-2 inhibition at low doses (Cryer & Feldman, 1998).

1.3 Beyond COX Inhibition

Recent research has revealed that some NSAIDs exert anti-inflammatory effects through mechanisms beyond COX inhibition. For instance, Wang et al. (2024) demonstrated that indomethacin inhibits nucleic acid-triggered type I interferon production by blocking the nuclear translocation of IRF3, suggesting a potential role in cytosolic nucleic acid-stimulated autoimmunity. This finding indicates that certain NSAIDs may have broader immunomodulatory properties than previously appreciated, though clinical implications remain to be fully elucidated.

2. Clinical Applications in Major Autoimmune Diseases

2.1 Rheumatoid Arthritis

In rheumatoid arthritis, NSAIDs are widely used as first-line therapy for rapid symptomatic relief of pain, joint swelling, and morning stiffness (Wirth et al., 2024). However, they do not prevent joint erosion or disease progression, and their use should be adjunctive to DMARD therapy.

The EULAR (European Alliance of Associations for Rheumatology) recommendations for RA management emphasize that NSAIDs should be used at the lowest effective dose for the shortest duration necessary, typically while waiting for DMARDs to achieve disease control over 2–3 months (Smolen et al., 2020). Glucocorticoids are often preferred over NSAIDs for bridging therapy due to their more predictable efficacy and disease-modifying potential, though combination therapy may be employed (Stouten et al., 2019).

A systematic review and meta-analysis of analgesic options for RA-related pain found that NSAIDs provide significant pain relief compared with placebo, with effects comparable to those of paracetamol but superior for inflammatory symptoms (Derry et al., 2017).

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2.2 Psoriatic Arthritis

For psoriatic arthritis, NSAIDs are recommended as first-line treatment for patients with mild disease and limited joint involvement. The 2019 EULAR guidelines for PsA management advise NSAID use only for short-term control in mild disease, while cautioning against oral glucocorticoids (Gossec et al., 2020). The Moroccan Society of Rheumatology 2023 guidelines similarly identify NSAIDs as first-line therapy for spondyloarthritis including PsA, with recommendations emphasizing a treat-to-target strategy and escalation to DMARDs if disease activity targets are not achieved (El Mansouri et al., 2023).

2.3 Axial Spondyloarthritis (including Ankylosing Spondylitis)

Axial spondyloarthritis represents a unique context in which NSAIDs play a particularly prominent role. Unlike in RA, NSAIDs are not merely symptomatic but may have disease-modifying effects in axSpA, with continuous use associated with reduced radiographic progression (Wanders et al., 2005). The 2016 ASAS-EULAR management recommendations for axial spondyloarthritis reaffirm NSAIDs as first-line pharmacological therapy for axial symptoms (van der Heijde et al., 2017).

Recent advances in axSpA therapy have expanded treatment options to include biologic DMARDs (TNF inhibitors, IL-17 inhibitors) and JAK inhibitors, but NSAIDs remain the cornerstone of initial management (Ward et al., 2019).

2.4 Juvenile Idiopathic Arthritis

In juvenile idiopathic arthritis, NSAIDs are often used as initial therapy, particularly in oligoarticular subtypes. Ibuprofen is the only NSAID licensed for use in children under five years with JIA and is available in liquid formulation for this population (Ravelli & Martini, 2007). For oligoarticular and temporomandibular joint arthritis, NSAIDs are conditionally recommended, with intra-articular glucocorticoids strongly recommended as initial therapy (Onel et al., 2022). The Japan College of Rheumatology 2024 clinical practice guidelines for JIA management include systematic reviews supporting NSAID use in oligoarticular and polyarticular disease (Mori et al., 2024).

2.5 Other Autoimmune Conditions

NSAIDs are also used in the management of other autoimmune and autoinflammatory conditions, including systemic lupus erythematosus (SLE), where approximately 80% of patients use NSAIDs as part of their treatment regimen (Fanouriakis et al., 2019), and in acute gout flares (FitzGerald et al., 2020). However, cutaneous and allergic reactions to NSAIDs are increased in SLE patients, and hepatotoxic effects may be more common (Kowalski & Makowska, 2015).

3. Efficacy: Evidence from Clinical Trials and Real-World Studies

The efficacy of NSAIDs for pain relief and functional improvement in autoimmune arthritis is well established. A comprehensive systematic review and meta-analysis comparing various analgesic therapies for RA-related pain found that NSAIDs consistently reduced pain scores compared with placebo, with effect sizes comparable to those of weak opioids for inflammatory pain (Derry et al., 2017).

Comparisons among individual NSAIDs reveal similar analgesic efficacy when administered at equipotent doses, though individual patient responses vary (Bindu et al., 2020). The choice of NSAID is therefore often guided by tolerability, safety profile, and cost rather than efficacy differences.

Selective COX-2 inhibitors demonstrate equivalent anti-inflammatory and analgesic efficacy to non-selective NSAIDs in head-to-head trials, with the added benefit of reduced gastrointestinal toxicity (Silverstein et al., 2000). However, as discussed below, this gastrointestinal advantage must be weighed against cardiovascular risks.

4. Safety Profiles and Adverse Effects

4.1 Gastrointestinal Toxicity

Gastrointestinal toxicity remains the most common adverse effect associated with NSAID use, ranging from dyspepsia to life-threatening ulceration, bleeding, and perforation (Scheiman, 2016). Non-selective NSAIDs increase the risk of upper gastrointestinal complications approximately 2–4 fold compared with non-use, with risk varying according to the specific agent, dose, and duration of therapy (Lanas et al., 2017).

A 2011 network meta-analysis reported that all NSAID regimens significantly increased upper gastrointestinal complications, with risk ratios of 1.81 for coxibs, 1.89 for diclofenac, 3.97 for ibuprofen, and 4.22 for naproxen compared with placebo (Trelle et al., 2011). More recent analyses have confirmed these findings (Mahmood et al., 2024).

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Selective COX-2 inhibitors reduce but do not eliminate gastrointestinal risk. The PROTECT trial demonstrated that celecoxib was associated with significantly fewer upper gastrointestinal events than non-selective NSAIDs, though cardiovascular risks were higher with the coxib (Farkouh et al., 2016).

Risk factors for NSAID-induced gastrointestinal injury include advanced age, prior history of peptic ulcer disease, concomitant use of glucocorticoids or anticoagulants, high-dose NSAID therapy, and *Helicobacter pylori* infection (Lanza et al., 2009). Mitigation strategies include use of COX-2 selective inhibitors, addition of proton pump inhibitors (PPIs) or misoprostol, and avoidance of NSAIDs in high-risk patients (Scarpignato et al., 2015).

4.2 Cardiovascular Risks

Cardiovascular safety concerns have significantly constrained NSAID use, particularly since the withdrawal of rofecoxib in 2004 due to increased myocardial infarction risk (Bresalier et al., 2005). Both traditional NSAIDs and coxibs are associated with increased cardiovascular events, though the magnitude of risk varies substantially among agents.

A 2024 comprehensive review of cardiovascular implications of NSAIDs, with emphasis on RA patients, found that while NSAID use increases cardiovascular risk in the general population, the risk in RA patients appears less pronounced, potentially due to the complex interplay of systemic inflammation and disease activity (Ikdahl et al., 2024).

A landmark network meta-analysis by Trelle et al. (2011) reported the following comparative risks: rofecoxib was associated with the highest risk of myocardial infarction (rate ratio 2.12), ibuprofen with the highest risk of stroke (3.36), and etoricoxib (4.07) and diclofenac (3.98) with the highest risk of cardiovascular death. Naproxen appeared least harmful among the agents studied. These findings have been replicated in subsequent large-scale observational studies (Bally et al., 2017).

The mechanism underlying NSAID-associated cardiovascular risk involves suppression of COX-2–derived prostacyclin (PGI_2) without concomitant inhibition of thromboxane A_2 (TXA_2), creating a prothrombotic state (Grosser et al., 2017). Traditional NSAIDs that also inhibit COX-1 reduce TXA_2 production, partially offsetting this effect, which may explain the relatively favorable cardiovascular profile of naproxen (Capone et al., 2005).

4.3 Renal Effects

NSAIDs can cause multiple forms of renal injury, including acute kidney injury (primarily hemodynamically mediated), electrolyte disturbances, hypertension, and chronic kidney disease (Whelton, 2000). Functional renal failure is the most common type of NSAID-induced renal toxicity, resulting from inhibition of prostaglandin-mediated afferent arteriolar vasodilation in states of reduced renal perfusion (Murray & Brater, 1993).

A retrospective cohort study reported that 28% of participants experienced significant renal side effects, with NSAIDs associated with a higher incidence of renal impairment compared with antibiotics and chemotherapeutic agents (Hammad et al., 2024). Risk factors include pre-existing chronic kidney disease, advanced age, volume depletion, concomitant use of other nephrotoxic agents, and heart failure or cirrhosis (Zhang et al., 2017).

The risk of NSAID-induced renal injury increases when estimated glomerular filtration rate (eGFR) falls below 60 mL/min/1.73 m^2, and NSAIDs are generally contraindicated when eGFR is <30 mL/min/1.73 m^2 (KDIGO, 2012).

4.4 Hypersensitivity Reactions

NSAID hypersensitivity reactions are common, affecting an estimated 0.5–2% of the general population (Kowalski et al., 2013). These reactions are classified into several clinical phenotypes: NSAID-exacerbated respiratory disease (NERD), NSAID-exacerbated cutaneous disease (NECD), NSAID-induced urticaria/angioedema (NIUA), and single NSAID-induced urticaria/angioedema or anaphylaxis (SNIUAA) (Kowalski & Makowska, 2015).

Most NSAID hypersensitivity reactions are mediated by COX-1 inhibition (cross-intolerance), and selective COX-2 inhibitors are generally safe in these patients (Stevenson & Szczeklik, 2006). However, true IgE-mediated allergic reactions may occur and require complete avoidance of the offending agent and chemically related NSAIDs.

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5. Clinical Limitations and Strategic Positioning

The fundamental limitation of NSAIDs in autoimmune disease management is their purely symptomatic effect: they do not alter the underlying disease process, prevent joint destruction, or induce remission (Wirth et al., 2024). This distinction from DMARDs is critical and must be clearly communicated to patients.

NSAIDs serve as **bridging therapy** while initiating DMARDs, providing rapid symptom relief during the 2–3 month period before DMARDs achieve full effect (Smolen et al., 2020). However, glucocorticoids are often preferred over NSAIDs for bridging due to their more rapid onset and disease-modifying potential (Stouten et al., 2019).

Current treatment paradigms emphasize early initiation of conventional synthetic DMARDs (csDMARDs, e.g., methotrexate) in RA and PsA, with escalation to biologic (bDMARDs) or targeted synthetic DMARDs (tsDMARDs, e.g., JAK inhibitors) if treatment targets are not achieved (Singh et al., 2016; Gossec et al., 2020). Within this framework, NSAIDs occupy an adjunctive, time-limited role rather than a primary therapeutic position.

6. Emerging Trends and Future Directions

6.1 Topical NSAIDs

Topical NSAIDs offer a promising alternative for localized joint pain, providing high local drug concentrations with minimal systemic exposure and reduced gastrointestinal side effects (Derry et al., 2016). Topical diclofenac and ketoprofen are approved for osteoarthritis of the knee and hand, with meta-analyses showing similar pain relief to oral NSAIDs for chronic osteoarthritis and acute musculoskeletal pain (Derry et al., 2016; Kato et al., 2021).

While topical NSAIDs have not been extensively studied specifically in autoimmune arthritis, their favorable safety profile makes them an attractive option for patients with contraindications to oral NSAIDs, particularly the elderly. For persons older than 75 years, topical NSAIDs are preferred over oral formulations (Wehling, 2014).

6.2 Nitric Oxide-Donating NSAIDs

Nitric oxide (NO)-donating NSAIDs represent a hybrid strategy designed to exploit the gastroprotective properties of NO while preserving anti-inflammatory efficacy (Wallace & Miller, 2020). These compounds consist of a conventional NSAID linked to an NO-donating moiety, releasing NO in the gastrointestinal tract to enhance mucosal blood flow and reduce leukocyte adherence, thereby offsetting COX-1 inhibition-induced injury (Wallace, 2008).

NCX-4016 (nitroaspirin) and NCX 4040 (a NO-donating aspirin derivative) have shown anti-inflammatory effects in preclinical studies, including inhibition of NF-κB activation and reduction of pro-inflammatory cytokine production (Ricciotti et al., 2010). Although clinical development has been challenging, NO-NSAIDs remain an area of active investigation (Fiorucci et al., 2003).

6.3 Dual-Acting Anti-Inflammatory Drugs

Dual-acting anti-inflammatory drugs that inhibit both COX and 5-lipoxygenase (5-LOX) pathways have been proposed as a strategy to achieve superior anti-inflammatory effects with reduced gastrointestinal toxicity (Bertolini et al., 2002). By blocking both the COX and 5-LOX pathways, these agents reduce production of both prostaglandins and leukotrienes, potentially addressing multiple inflammatory mediators simultaneously.

Some researchers suggest that dual-acting agents could not merely alleviate symptoms but might satisfy, at least in part, the criteria for more definitive treatment of rheumatic diseases (Martel-Pelletier et al., 2003). Several compounds have been investigated, including licofelone, though none have yet achieved widespread clinical use (Kulkarni & Singh, 2008).

6.4 Novel NSAID Conjugates and Prodrugs

Recent medicinal chemistry efforts have focused on developing novel NSAID conjugates with enhanced selectivity and reduced toxicity. El-Sayed et al. (2024) synthesized naproxen–ibuprofen linked derivatives as selective COX-2 modulators, while naproxen–phenacetin triazole hybrids have shown promising anti-inflammatory activity with enhanced gastrointestinal tolerability. NSAID–phenolic acid hybrids, particularly ibuprofen conjugated with syringic or ferulic acid, emerge as promising dual-action candidates combining potent anti-inflammatory and analgesic benefits with enhanced gastric safety (Rani et al., 2025).

6.5 Targeted Drug Delivery Systems

Advanced drug delivery systems are being developed to enhance NSAID targeting to inflamed joints while minimizing systemic exposure. Approaches include:

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- **Nanoparticle-based delivery:** Aceclofenac-loaded polymeric nanoparticles in transdermal hydrogels have been developed for RA management (Baviskar et al., 2025).
- **Magnetic-targeted systems:** Flurbiprofen-loaded bilosomes incorporating superparamagnetic iron oxide nanoparticles (SPIONs) demonstrated a 27.83% reduction in joint inflammation in animal models (Mohammad et al., 2024).
- **Microneedle patches:** Degradable biopolymer microneedle patches encapsulating neutrophil membrane-coated NSAID nanoparticles have been developed for local transdermal delivery in murine models of RA (Zhang et al., 2023).

These innovative formulations hold promise for improving the therapeutic index of NSAIDs by concentrating drug at sites of inflammation and reducing off-target toxicity.

7. Practical Management and Risk Mitigation

Evidence-based strategies for optimizing NSAID therapy in autoimmune diseases include:

Risk Assessment Before Prescribing

- Evaluate gastrointestinal risk factors (age >65 years, prior ulcer, concomitant glucocorticoids/anticoagulants, *H. pylori* infection) (Lanza et al., 2009)
- Assess cardiovascular risk factors (hypertension, diabetes, dyslipidemia, prior cardiovascular events, chronic kidney disease) (Grosser et al., 2017)
- Check renal function (eGFR) and blood pressure at baseline (Whelton, 2000)

Agent Selection

- For high gastrointestinal risk: Consider COX-2 selective inhibitor OR non-selective NSAID plus PPI (Scarpignato et al., 2015)
- For high cardiovascular risk: Naproxen may be preferred, but caution is still warranted; avoid diclofenac and high-dose ibuprofen (Trelle et al., 2011)
- For patients with eGFR <60 mL/min/1.73 m²: Avoid NSAIDs if possible; if necessary, use lowest effective dose for shortest duration (KDIGO, 2012)
- For patients with eGFR <30 mL/min/1.73 m²: NSAIDs are contraindicated

Dosing and Duration

- Use the lowest effective dose for the shortest duration necessary (Wirth et al., 2024)
- Avoid concurrent use of multiple NSAIDs or aspirin (unless low-dose aspirin is indicated for cardiovascular protection) (Antman et al., 2007)
- Reassess need for continued NSAID therapy at each visit

Monitoring

- Monitor blood pressure, serum creatinine, and electrolytes periodically during long-term therapy (De Vecchis et al., 2022)
- Educate patients about symptoms of gastrointestinal bleeding, cardiovascular events, and renal impairment

Special Populations

- **Pregnancy:** Coxibs should be prohibited throughout pregnancy; avoid NSAIDs in third trimester (Flint et al., 2016)
- **Elderly (>75 years):** Topical NSAIDs preferred when appropriate; if oral NSAIDs required, use lowest dose and co-prescribe PPI (Wehling, 2014)
- **Concomitant methotrexate:** NSAIDs plus methotrexate may cause a brief mild increase in blood abnormalities, particularly if taken on the same day as methotrexate (Bourré-Tessier & Haraoui, 2010)

Conclusion

Non-steroidal anti-inflammatory drugs remain valuable therapeutic agents for the symptomatic management of autoimmune rheumatic diseases. Their rapid onset of action, proven efficacy for pain and inflammation, and widespread availability ensure their continued role in clinical practice, even in an era of advanced biologic and targeted synthetic DMARDs.

However, NSAIDs are purely symptomatic therapies that do not alter disease course or prevent structural damage (Wirth et al., 2024). Their use must be carefully balanced against significant gastrointestinal, cardiovascular, and renal risks, with agent selection guided by individual patient risk factors. Selective COX-2

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inhibitors offer gastrointestinal advantages but carry cardiovascular concerns, while naproxen appears least harmful from a cardiovascular perspective but retains gastrointestinal risks (Trelle et al., 2011; Grosser et al., 2017).

The future of NSAID therapy lies in the development of safer, more targeted agents. Topical formulations reduce systemic exposure; nitric oxide-donating hybrids and dual-acting compounds address multiple inflammatory pathways while potentially mitigating toxicity; and advanced drug delivery systems promise enhanced targeting to inflamed tissues (Wallace & Miller, 2020; Mohammad et al., 2024). As these innovations progress toward clinical translation, they may expand the therapeutic window of NSAIDs and improve outcomes for patients with autoimmune diseases.

Ultimately, rational NSAID prescribing requires individualized risk-benefit assessment, adherence to evidence-based guidelines, and integration within comprehensive disease management strategies centered on DMARD therapy. By optimizing NSAID use in this manner, clinicians can maximize symptomatic relief while minimizing harm in patients with autoimmune diseases.

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No original datasets were generated for this review article. All cited data and findings are available within the original research publications referenced in the manuscript, accessible via the provided Digital Object Identifiers (DOIs) or through respective journal platforms.

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