

关于预防踝关节骨关节炎的研究进展

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摘 要

目的: 归纳总结近10年关于踝关节炎(OA)预防的研究进展。通过这些预防策略优化踝关节遭受创伤后的诊断及治疗, 从而降低踝关节OA的发生率。方法: 从Embase、PubMed以及Web of science数据库中检索2004年至2024年关于踝关节OA预防的随机对照试验、队列研究、病例对照研究以及系统综述等研究类型, 无语言限制。检索关键词包括“踝关节炎(ankle arthritis)”和“预防(prevention)”, 同时结合其同义词和相关术语进行检索, 以确保文献检索的全面性。此外, 还手工检索了相关参考文献列表, 以补充数据库检索可能遗漏的重要文献。纳入能够有效预防踝关节OA发展的临床研究。排除重复发表的研究和设计不合理、数据不完整或统计方法错误的低质量研究。结果: 研究显示, 踝关节OA的预防策略涵盖包括健康管理、保守治疗、手术干预、生物制剂以及影像技术应用在内的多个方面。坚持健康的生活方式或开展基于运动的预防干预项目、利用新兴影像技术指导踝关节创伤后的早期预防性治疗、对于踝关节韧带损伤采用保守治疗或者踝关节镜下韧带重建、对于踝关节内大面积骨软骨缺损采用自体骨软骨植骨术、对移位性踝关节内骨折采用切开复位内固定等都能有效预防踝关节OA的发展。生物制剂目前已显示出疾病预防的良好应用前景, 但对其临床转化及长期治疗效果的评估仍任重道远。结论: 健康管理、保守治疗、手术干预、生物制剂以及影像技术的应用对于预防踝关节OA的发展均是有效的, 但部分干预措施的长期应用效果检测, 如生物制剂应用, 在未来仍需要进一步的前瞻性临床试验。

关键词

踝关节炎, 预防

Research Progress on the Prevention of Ankle Osteoarthritis

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Abstract

Objective: To summarize the research progress on the prevention of ankle arthritis (OA) over the past decade. By optimizing the diagnosis and treatment of ankle injuries through these preventive strategies, the incidence of ankle OA can be reduced. **Methods:** We searched for randomized controlled trials, cohort studies, case-control studies, and systematic reviews on the prevention of ankle osteoarthritis from 2004 to 2024 in the Embase, PubMed, and Web of Science databases, with no language restrictions. The search terms included “ankle arthritis” and “prevention”, along with their synonyms and related terms, to ensure the comprehensiveness of the literature search. Additionally, we manually reviewed the reference lists of relevant articles to identify important studies that might have been missed by the database search. Studies that could effectively prevent the development of ankle osteoarthritis were included. Studies with duplicate publications and those with poor quality due to unreasonable design, incomplete data, or erroneous statistical methods were excluded. **Results:** Studies have shown that preventive strategies for ankle osteoarthritis cover multiple aspects, including health management, conservative treatment, surgical intervention, bioactive agents, and the application of imaging techniques. Adhering to a healthy lifestyle or implementing exercise-based preventive programs, using emerging imaging technologies to guide early preventive treatment after ankle trauma, adopting conservative treatment or arthroscopic ligament reconstruction for ankle ligament injuries, performing autologous osteochondral grafting for large osteochondral defects in the ankle joint, and using open reduction and internal fixation for displaced intra-articular ankle fractures can all effectively prevent the development of ankle OA. Bioactive agents have demonstrated promising applications in disease prevention, but the assessment of their clinical translation and long-term therapeutic effects remains a significant challenge. **Conclusion:** Health management, conservative treatment, surgical intervention, bioactive agents, and the application of imaging techniques are all effective in preventing the development of ankle osteoarthritis. However, the long-term effects of certain interventions, such as the use of bioactive agents, require further investigation through prospective clinical trials.

Keywords

Ankle Osteoarthritis, Prevention

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1. 引言

众所周知, 踝关节很少发生原发性骨关节炎[1]-[5], 在大多数情况下(70%~78%)是发生创伤后骨关节炎(PTOA) [6] [7], 常见致病因素包括关节内骨折、距骨骨软骨缺损以及踝关节韧带损伤。踝关节 OA 在创伤后的发展机制尚未被充分理解, 但机械因素, 如关节对位不良、关节面复位不良以及韧带不稳, 均被认为与之相关[8]-[10]。此外, 踝关节骨折后骨关节炎的发展还与关节内持续存在的炎症微环境有关[11] [12]。

踝关节 OA 患病率在 50 岁以上的普通人群中约为 3.4% [2], 在退役足球运动员或橄榄球运动员等运动活跃人群中则更高[13]。通过优化踝关节损伤后的诊断和治疗以减少关节畸形和不稳定, 或许有助于减少 OA 的发生。为此, 本文综述了近 10 年来关于踝关节 OA 预防的研究进展, 旨在为临床医生提供科学依据以更好地预防和治疗该疾病, 减轻患者痛苦和社会经济负担。

2. 踝关节骨关节炎的预防策略

2.1. 健康管理

已知吸烟、较高的体质指数和其他出现疼痛、酸痛或僵硬的关节(如肩、肘、腕、手、髌、膝、足等)的数目增多是导致踝关节 OA 发生的非创伤性可调节风险因素[1], 通过戒烟、保持健康体重和预防其他关节损伤, 有助于降低踝关节 OA 在普通社区居民中的发生率。此外, 针对职业运动员开展基于运动的预防干预项目是有必要的。以足球中的 FIFA 11+和橄榄球中的运动控制损伤预防项目为例, 二者均已被证实可有效降低踝关节损伤发生率[14][15]。健康管理的重要性不可忽视, 但长期坚持健康生活方式本身具有较大挑战性, 另外运动预防项目需要专业指导, 实施成本可能较高。

2.2. 保守治疗

大约 85%的踝关节损伤为外侧踝关节扭伤[16]。此前许多文献已报道单次和反复踝关节扭伤的长期影响均与创伤后踝关节骨关节炎(PTOA)的发展有关[6][7][13][17]-[20]。踝关节扭伤及韧带撕裂多发于运动和日常生活中, 其中踝关节外侧韧带复合体最常受损[21][22]。除了孤立的外侧韧带复合体损伤, 大多数踝关节扭伤患者还同时伴有下胫腓联合损伤、三角韧带损伤、骨软骨病变、骨挫伤和骨折(如撕脱性骨折)等[23][24]。约 75%的踝关节扭伤涉及韧带完全撕裂[25], 其中 80%为距腓前韧带(ATFL)撕裂, 20%为 ATFL 和跟腓韧带(CFL)同时撕裂[25]-[27], 而这两种情况均会导致距骨前移增加[28], 进而降低踝关节的机械稳定性。多达 70%的急性踝关节扭伤患者还可能发展为慢性外侧踝关节不稳(CLAI), 进而导致长期功能障碍[17][18][29]-[31], 并增加踝关节 OA 的风险[13][17]-[19]。

CLAI 具体表现包括持续疼痛、症状性不稳、机械性不稳和功能不稳, 这主要是由于踝关节反复扭伤及关节损伤后韧带未能完全愈合[32][33]。与大多数踝关节韧带损伤首选保守的非手术治疗类似, 临床上慢性踝关节不稳定初始治疗同样采用保守治疗[34][35], 包括休息、冰敷、加压包扎和抬高患肢(RICE 原则)以及提供踝关节支具支持, 大部分患者经过治疗后能够恢复踝关节的稳定性。CLAI 的二级治疗目标是预防踝关节不稳定导致的骨关节炎等并发症, 通过本体感觉训练、神经肌肉训练以及使用支具来预防踝关节扭伤的复发对实现该目标至关重要, 具有一定成本效益[36][37]。

2.3. 手术干预

当保守治疗对慢性踝关节不稳定无效且韧带变得松弛时, 可考虑手术治疗[38][39]。手术重建韧带可分为解剖重建和非解剖重建两种[40][41], 前者在长期效果上更为理想[42]-[44]。踝关节镜下韧带解剖重建作为一种微创手术方法, 其效果在过去二十几年中稳步提升。这种技术的突出优势在于创伤小且并发症少[45]。对于职业运动员, 尤其是那些患有 III 级外侧韧带损伤的运动员, 建议尽早进行急性外侧韧带修复手术, 以降低非手术治疗失败的风险, 从而避免更长时间的恢复期并提高重返赛场的可能性[46]-[49]。据报道, 踝关节镜手术重建外侧韧带的并发症发生率为 9%~17%, 其中以术中神经血管损伤最为常见, 例如腓浅神经损伤[50]-[53]。因此了解踝关节区域的解剖结构基础知识, 尤其是浅层和深层神经血管结构, 是骨科医生选择微创手术方法的关键, 以避免术中损伤并预防术后并发症[54]。

踝关节扭伤可导致骨软骨病变的发生率升高[55]。一项关于 41 名 CLAI 接受外侧韧带重建的患者的最新研究发现, 32%的患者存在距骨骨软骨病变[56]。病变较大及受累的骨软骨碎片发生剥脱和移位会改变关节的正常力学特性, 最终导致骨关节炎的发生。关节镜下微骨折术因其微创性, 在治疗小面积骨软骨缺损病变方面相比开放手术具有显著优势, 在临床中的使用也最为广泛。文献中有大量研究报告显示, 微骨折技术取得了良好到极佳的结果[57]-[61], 但该技术对大面积骨软骨缺损的效果较差[62]-[64]。因大

面积骨软骨缺损的最佳治疗方案是实现特定类型的透明软骨的长期替代和整合, 原则上传统的马赛克植骨术、近几年新发展的踝关节镜下结合生物支架以及取自胫骨平台的自体松质骨移植技术均符合这些标准[65]。马赛克植骨术通过从同侧膝关节的非负重区或低负重区(如内/外侧股骨嵴)获取健康的骨软骨柱状移植物并将其移植到距骨缺损部位以达到修复效果, 在帮助患者尽早恢复踝关节功能及预防骨关节炎的发生方面显示出巨大潜力[66] [67]。然而, 该技术采用开放手术入路, 并需要进行距骨踝突截骨术。可能会出现供体部位并发症以及与距骨踝突截骨相关的并发症, 例如不愈合、延迟愈合或移植失败[66] [68] [69]。踝关节镜下结合生物支架以及取自胫骨平台的自体松质骨移植技术是一种新发展起来的关节镜手术技术[70], 可作为马赛克植骨术在治疗深部距骨骨软骨病变中的替代方法[65]。该技术的显著优势在于其完全通过关节镜操作, 无需额外切口获取移植骨, 利用关节镜入路完成移植骨的获取, 避免了供体部位并发症, 且无需进行踝突截骨术[70]。

除了外踝扭伤, 关节内骨折同样是诱导 PTOA 发生的重要病因, 可导致软骨损伤和韧带不稳定[6] [7] [20] [71]-[74]。目前, 切开复位内固定(ORIF)是移位性踝关节内骨折的标准治疗方法[75]。随着先进影像技术的发展和应用, 通过实施更精细的手术重建技术来恢复踝关节解剖对位, 有望降低 PTOA 的发生率, 但这也同时带来了手术时间延长及术后并发症风险增高的问题。

2.4. 生物制剂

许多涉及 PTOA 发展的机制已被提出作为潜在的治疗靶点, 例如针对踝关节中具有独特活性的 IL-1 和 TNF 等促炎细胞因子使用其受体的靶向拮抗剂[76] [77]、针对软骨细胞内活性氧增多使用抗氧化剂[78], 已在动物实验中证实可抑制骨关节炎的进展。尽早实现这些生物制剂的临床转化并将其与手术干预结合, 有望进一步减少 PTOA 的发生。

富含血小板的血浆(Platelet Rich Plasma, PRP)在运动相关损伤的治疗应用中越来越广泛, 被认为可以刺激组织愈合[79] [80]。目前已有文献报道外踝扭伤导致距胫前韧带完全撕裂的患者在接受富血小板血浆(PRP)治疗后, 表现出韧带完全愈合以及踝关节早期稳定, 结果得到了动态超声图像和磁共振成像(MRI)的支持[81]。因此, 富血小板血浆(PRP)在未来也可能作为外踝扭伤行保守治疗无效时的替代性非手术治疗选择, 帮助患者恢复韧带强度、减少韧带松弛和实现早期踝关节稳定, 并有望预防 PTOA 的发展。但在未来需要展开更多前瞻性临床试验对该干预措施的长期治疗效果进行检测。

2.5. 影像技术

目前临床评估踝关节对齐及监测踝关节 OA 涉及连续获取负重 X 线片, 并采用 Kellgren 和 Lawrence (KL)分级进行评分[82]。然而, X 线片技术仅能捕捉踝关节三维结构及病理的模糊二维投影。相比之下, 低剂量负重 CT 能够提供对关节对齐、稳定性和退变更为敏感的测量结果, 且不会显著增加成本、时间及辐射暴露[83]。因此, 低剂量负重 CT 可用于指导踝关节损伤后的早期预防性治疗, 通过使用支具或重建韧带来解决关节错位和韧带不稳的问题, 以治疗踝关节扭伤或严重踝关节骨折重建后的慢性踝关节不稳。

此外, 双平面荧光透视是一种涉及两台校准的荧光透视仪捕捉动态视频以评估日常活动中各个骨骼三维运动学的技术, 因其高度精确的体内骨骼运动学追踪特性, 它能够检测到踝关节创伤后细微的功能差异(即退行性关节疾病早期标志), 非常适合研究 PTOA 随时间的发展[84]-[89]。

3. 结论与未来研究方向

本文综述了踝关节 OA 的多方面预防策略, 不仅涵盖了从生活方式调整到手术干预的多种手段, 还突出了针对踝关节损伤后的早期诊断和精准治疗的重要性。未来的研究应聚焦于开发更精准的影像学工

具以实现踝关节损伤后的早期诊断和个性化干预、进一步探索各类生物制剂在踝关节损伤修复和骨关节炎预防中的长期治疗效果、不断优化手术技术和完善术后康复训练方案, 以加快患者踝关节的功能恢复。此外, 开展国际多中心研究以进一步验证不同预防策略在不同人群中的有效性和适用性是必要的, 这样做能够为全球范围内的临床实践提供更可靠的科学依据。

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