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Short commentary

A Summary of Advancements in Osteoporosis Management

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Abstract

Osteoporosis is a major global health issue that affects millions of people, leading to many fractures and related problems. According to the American Association of Clinical Endocrinologists, about 10.2 million Americans have osteoporosis, resulting in over 2 million fractures each year. Despite advancements in diagnostic tools like the DXA scan and the FRAX® tool, osteoporosis is still often underdiagnosed and undertreated. Diagnosing osteoporosis and considering management with treatment options for managing osteoporosis using the latest guidelines and emerging technologies may improve early detection and create more personalized treatment plans. Public health initiatives and educational resources are crucial in spreading awareness and helping people be proactive regarding their bone health. Those who are aware of their osteoporosis currently have access to various methods to identify the disease and slow its progression through a combination of exercise, lifestyle changes, and medication. New approaches, including machine learning and wearable technology, show great promise in assessing fracture risk and improving patient care. A comprehensive and integrated strategy is essential for better outcomes and quality of life for those with osteoporosis worldwide.

Introduction

Osteoporosis and osteoporotic fractures are global issues. The American Association of Clinical Endocrinologists estimates that 10.2 million Americans have osteoporosis, with more than 2 million osteoporosis-related fractures occurring annually in the U.S [1]. The Clinical Practice Guideline for Osteoporosis Screening and Treatment define osteoporosis as a condition resulting characterized as gradual decrease in bone mass over time, which compromises bone integrity and an increases bone vulnerability to fracture. Current estimations indicate that approximately 33% of women and 20% of men over the age 50 will experience osteoporotic fractures in their lifetime [2]. In the past five years, 4 million fractures have been recorded and are projected to increase 20% by 2035 in Europe [3]. The number of osteoporosis-related fractures in China is projected to increase from 2.33 million in 2010 to 5.99 million by 2050 [4].

The most devastating outcome of osteoporosis and low bone density are osteoporotic fractures in the vertebrae (lumbar spine), proximal femur (hip) and distal forearm (wrist). These fractures can have a full recovery, but may also lead to disability, morbidity, and premature death. Other impacts include emotional distress, reduced mobility, changes in daily activities, increased reliance on others for assistance, and challenges in maintaining social connections. These factors contribute to an overall decrease in the quality of living. Although there are various diagnostic tools and treatment methodologies, osteoporosis is currently underdiagnosed and undertreated. Fractures can result in chronic pain, disability, and even premature death, affecting quality of life significantly. Hip, vertebral, and wrist fractures are particularly challenging, causing mobility issues and psychological distress like depression and low self-esteem. Osteoporosis- related fractures, common in older adults, add to these challenges, emphasizing the need for comprehensive care addressing physical, emotional, and social aspects for optimal recovery and well-being. Given the predicted global implication of osteoporosis in the coming years, innovative measures are being introduced in attempt to diagnose osteoporosis, improve bone density for those at risk, and prevent osteoporotic fractures.

Osteoporosis Diagnosis and Awareness

The "Current Guidelines on Management for Osteoporosis" by AACE recommends that screening efforts to detect osteoporosis should be initiated for women aged 65 and older, as well as men aged 70 and older. However, individuals with specific risk factors, such as calcium or vitamin D deficiency, a body weight below 127 lbs (57.6 kg), or factors like poor vision, dementia, frailty, and a history of falls, should start screening at the age of 50. The clinical indication for osteoporosis is a low trauma fracture without metabolic bone disease. The gold standard for osteoporosis diagnosis is a Bone Mineral Density Assessment known as the Dual-energy X-Ray Absorptiometry Scan (DXA Scan) The results from a DXA scan are a T-Score and Z-Score, with the former offering a comparison between the BMD of a younger adult, and the latter offering a comparison against others with the same age, size, sex, race and ethnicity. A T-Score less than or equal to -2/5 calculated at lumbar, femoral neck, or hip is a threshold of treatment and diagnosis. A Z-score that is less than -2.0 is considered as potentially osteoporotic while a Z-Score that is greater than a -2.0 is considered normal for the demographic.

The Absolute Fracture Risk (FRAX®) is often used in conjunction with DXA to indicate the need for intervention. The FRAX is an online tool used to evaluate risk factors that can include bone mineral density by estimating a person's probability of osteoporotic fracture over a period of 10 years. The FRAX was originally released in 2008 and has continued to evolve with inclusion of new tools to offer more accurate identification [5].

The emergence of more sophisticated tools in the field addresses the limitations of previous approaches by enabling evaluation of bone

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strength and fragility. The Trabecular Bone Score (TBS) leverages DXA data to provide understanding of bone strength independent of density. The Hip-Axis Length (HAL) measure is a more targeted and focuses on hip fracture risk by considering anatomical factors [6]. The recently updated FRAX model released in 2023 and most recently again in 2024 that is known as FRAXplus® integrates an updated ability to modify probability results for more individualized screening including the updated factors of TBS and the HAL [5]. Other advanced tools that address limitations include Finite Element Analysis (FEA), which models bone strength by considering its structural attributes. FEA analyzes bone structure, considering geometry, material properties, and loads. It creates digital bone models to predict responses to different forces and conditions. Radiofrequency Echographic Multispectrometry (REMS) utilizes ultrasound to detect different fracture risks and has the ability to identify various factors that contribute to fracture risks, including bone density variations, structural abnormalities, and composition changes [6].

In late 2023, UK-based Naitive™ Technologies announced their OsteoSight™ technology received Breakthrough Device Designation by the United States Food and Drug Administration. This technology aims to improve early detection rates of osteoporosis and low bone density by analyzing large numbers of routine X-rays for related insights that may have otherwise gone unnoticed. "By automatically including an estimate of bone density, along with an osteoporosis classification based on World Health Organization (WHO) guidelines, into the radiology report, physicians can be alerted sooner to their patient's bone health" [7]. These advancements collectively contribute to a more accurate and personalized assessment of fracture risk in osteoporosis.

Magnetic Resonance Imaging (MRI), has recently been found in research to offer opportunistic diagnostic differentiation for the presence of osteoporosis, but with less sensitivity than DXA. An MRI output of M-score lower than 1.26 signifies normal bone density, while an M- score between 1.26 and 2.05 denotes osteopenia. However, according to this study, the MRI will not replace DXA as this remains the optimal approach for diagnosing osteoporosis, assessing BMD, and assessing the response to treatments. Differentiates between osteoporosis and other primary mineralization deficiencies (structure defects) [8]. Machine learning has the ability to analyze complex data sets in medical records that have the potential to go beyond the limitations traditional risk algorithms. This technology holds the capacity to process numerous clinical variabilities simultaneously in an automized manner and more precisely analyze fracture risk. With and without use of existing standard methodologies, machine learning will enable enhanced care which is crucial to the future of fracture risk identification. These machine learning algorithms and methodologies, in addition to being non- invasive, may also forecast which intervention techniques would produce the most optimal therapeutic outcomes for each patient [6].

Early identification through awareness of bone loss is a critical component of providing treatment in a timely manner. Osteoporosis Awareness Month in the United States, and World Osteoporosis Day are two examples of annual public health initiatives that promote awareness to clinicians and the public. Additional resources are made available to individuals by advocacy groups, government-based organizations, etc. with the purpose of providing education and reliable information. For example, the Fracture Risk Calculator via American Bone Health, Your Path to Good Bone Health via the Bone Health & Osteoporosis Foundation (BHOF), and educational guides from the National Institutes of Health (NIH) aim to empower individuals to take ownership of their osteoporosis journey.

Osteoporosis Treatment and Fracture Avoidance

The management of osteoporosis often involves a multifaceted approach, incorporating various medications and lifestyle interventions. Commonly prescribed medications often aim to either slow down bone loss or promote bone formation. The first choice for a medication-based treatment are Bisphosphonates which inhibit bone resorption. Other common medications include RANKL inhibitors, such as denosumab (Prolia), hormone-related therapies, bone-building medications like teriparatide and abaloparatide, and supplements such as calcium and vitamin D. In tandem with medication, engaging in weight-bearing or strength training exercises is crucial for maintaining bone tissue and reducing the rate of bone loss. A balanced diet, rich in essential nutrients, complements these efforts. However, individuals with osteoporosis may face challenges in participating in such exercises due to weakness and fear of fractures. Overcoming these challenges requires tailored exercise programs and guidance from healthcare professionals to ensure safety and effectiveness in promoting bone health [1]. It is important for individuals with osteoporosis to seek guidance from their healthcare team before starting any exercise regimen.

According to the Mayo Clinic, physical therapy interventions for osteoporosis focus on improving bone health, reducing fracture risk and enhancing overall physical function. Weight bearing mobility and exercise also play an important role in slowing the progression/severity of osteoporosis, additional bone loss as resistance training with weights or bands targeting major muscle groups, balance and stability exercises to prevent falls, core strengthening for spinal support, flexibility exercises to maintain joint mobility, posture training to reduce strain on the spine, and, in some cases, aquatic exercises for low-impact training. Activities that involve high- impact or risky movements should be avoided to minimize fracture risk [9]. Recognizing these benefits, multiple public health campaigns, initiatives, and programs have been established through a number of organizations to encourage safe mobility and weight bearing exercise for older adults, especially those at risk of falls and osteoporotic fracture. Examples include Stopping Elderly Accidents, Deaths & Injuries (STEADI), freely available virtual Exercise and Wellness classes hosted by AARP (often without membership requirements), and Falls Prevention Awareness Week organized by the National Council on Aging (NCOA).

Recognizing the prevalence of falls, and impact fall-related injuries and fractures can have for older adults, especially those with osteoporosis, fall prevention is an important aspect related to older adult safety. One of the first intervening steps for patient safety is often home modification, such as adjusting furniture, installing grab bars & railings, or improving lighting. The Centers for Disease Control and Prevention (CDC) provides a free brochure to help elders consider aspects within their home setting that may need updating for continued fall-related safety. The freely available "Check for Safety: A Home Fall Prevention Checklist for Older Adults" is easily accessed for this reference.

Garments designed with specialized padding for strategic anatomical protection in the event of a fall has been popular for many years, and in some instances, has been clinically verified as effective. One

large study showed greater than 80% reduction in risk of fracture if a hip protector is worn at the time of fall by ambulatory, at risk elderly adults [10]. Citing difficulties with adherence for some [10], manufactures have attempted to address limitations with traditional, rigid hip protection pads by utilizing newer materials, such as softer impact-absorbing foam, often paired with more body-contoured integrations into undergarments, belts and clothing for ease of use.

Emerging technologies are offering wearable airbag devices marketed for older adults susceptible to fall-related injury & fracture. These devices claim the ability to sense falls in progress, and quickly inflate one or multiple airbags to offer strategic protection, mitigating fall- impact forces to the hips, pelvis, and/or head, depending on the product. Blending modern technology into traditional form factors such as a chest-worn vest, undergarments, or a waist worn belt, these products appear to integrate into the user's life with minimal disruption, hopefully allowing for greater protection and user adherence.

Conclusion

Osteoporosis represents a critical healthcare challenge that remains underdiagnosed and undertreated despite it affecting millions worldwide, with a substantial burden of fractures and associated morbidity. Fortunately, there have been expansions to proven methodologies and interventions. The advancements in diagnostic tools offer a more nuanced and personalized approach to early detection and risk assessment. Technological innovations such as MRI and machine learning algorithms hold promise for optimizing risk prediction and enhancing preventive measures. Public health initiatives and educational resources play a pivotal role in raising awareness, empowering individuals, and fostering proactive approaches to bone health. Treatment strategies, ranging from medications to lifestyle interventions and physical therapy, underscore the multidimensional nature of managing osteoporosis and mitigating fracture risks. Emerging strategies such as wearable technology partnered with these foundational treatments holds promise as well. Collaboration across healthcare sectors, continued research endeavors, and advocacy efforts are imperative to address gaps in diagnosis, treatment access and long- term management of osteoporosis. Ultimately, a comprehensive and integrated approach, coupled with ongoing innovation and advocacy, is key to improving outcomes and quality of life for individuals impacted by osteoporosis globally.

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