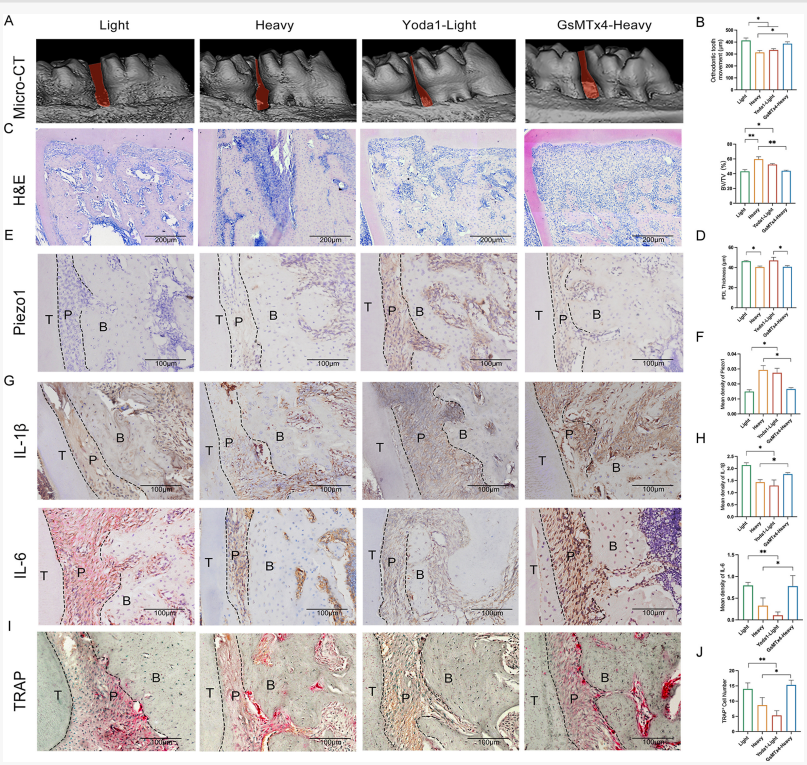
Unraveling the Mechanism Behind Orthodontic Tooth Movement

SHANNON, CLARE, IRELAND, March 2, 2025 /EINPresswire.com/ -- A new study in Genes & Diseases has revealed that heavy mechanical force can decelerate orthodontic tooth movement (OTM) by altering the way periodontal ligament cells (PDLCs) respond to stress. The authors of this article have identified the key role of Piezo1, a mechanosensitive ion channel, in controlling this process by regulating mitochondrial calcium levels, ultimately affecting bone remodeling.



Heavy mechanical force (MF)-activated Piezo1 decelerates orthodontic tooth movement (OTM) in vivo.

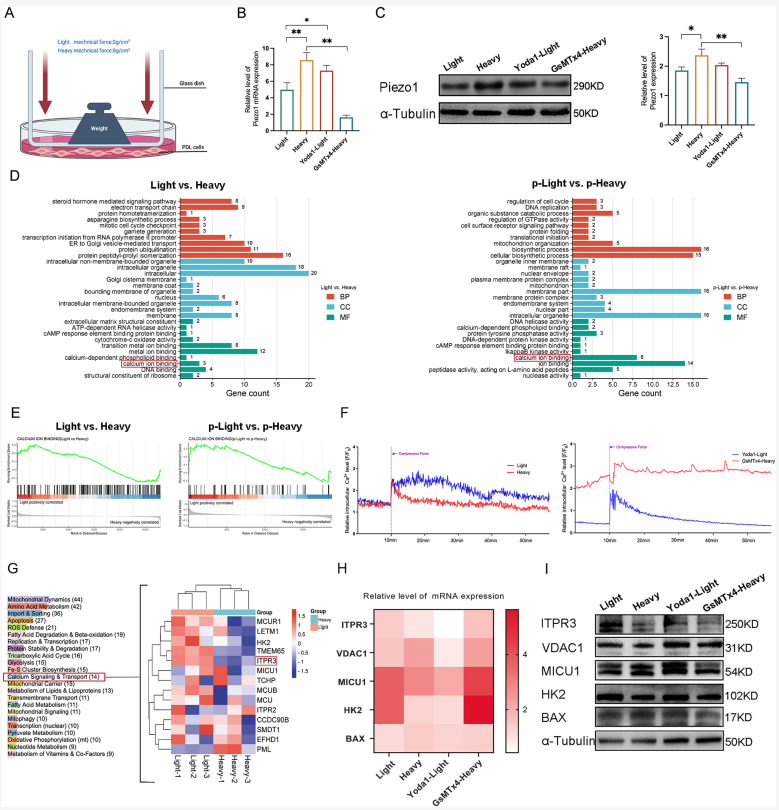
Orthodontic tooth movement is driven by the body's response to mechanical forces applied during treatment. While light mechanical forces are known to optimize movement by promoting bone remodeling, excessive force has been observed to slow down the process. This study explains the cellular mechanisms behind this phenomenon and provides potential therapeutic targets to improve treatment efficiency.

It was discovered that heavy force upregulates Piezo1 expression in periodontal ligament cells, disrupting mitochondrial calcium homeostasis. This occurs through the inhibition of ITPR3, a key calcium transporter in mitochondria-associated membranes (MAMs). The resulting reduction in mitochondrial calcium uptake leads to lower cytoplasmic mitochondrial DNA release, ultimately suppressing the cGAS–STING signaling pathway—a crucial regulator of osteoclast activity. Since osteoclasts are responsible for breaking down bone tissue to allow tooth movement, their suppression under heavy mechanical force leads to slower tooth repositioning.

In experiments involving both animal models and in vitro studies, the authors found that

blocking Piezo1 activity or enhancing STING signaling could restore osteoclast function and accelerate tooth movement under heavy force conditions. These findings suggest that targeting Piezo1 or its downstream pathways could help optimize orthodontic treatment strategies, allowing for more predictable and efficient tooth realignment.

This research not only enhances understanding of biomechanical force transduction in orthodontics but also opens new avenues for developing pharmacological interventions that could improve treatment outcomes. By fine-tuning the balance of mechanical force and cellular signaling, clinicians may be able to personalize orthodontic treatments for faster and safer results.



Heavy mechanical force (MF) conditions activate Piezo1-inhibited ITPR3 in periodontal ligament stem cells.

The findings mark a significant step forward in orthodontic science, shedding light on how force application impacts cellular behavior and offering a roadmap for future innovations in tooth movement acceleration strategies.

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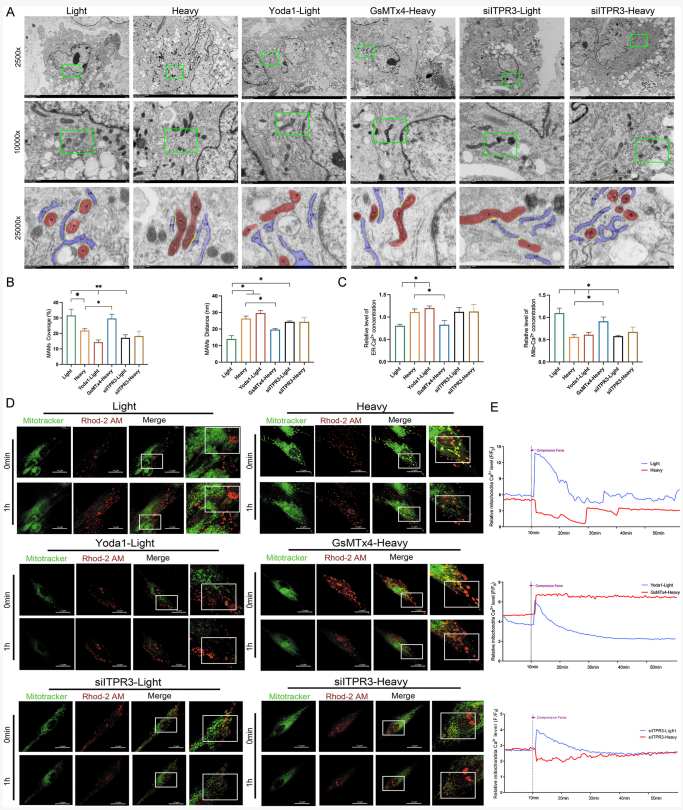

Heavy mechanical force (MF)-activated Piezo1 down-regulates [Ca2+]m levels by inhibiting ITPR3 in mitochondria-associated membranes.

Reference
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