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Review

From Plaster to Pixels: The Evolution of Offloading in the Diabetic Foot

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Abstract

Offloading remains the cornerstone of diabetic foot ulcer (DFU) management. This review traces the evolution of mechanical offloading from early plaster casting in South Asian leprosy clinics to modern removable walkers and emerging "SmartBoot" technologies. We examine the historical progression from total contact casting (TCC) through the era of randomized trials and instant TCC (iTCC), up to the current integration of wearable sensors and digital adherence tools. Contemporary evidence—including meta-analyses—is discussed to compare the effectiveness of offloading modalities (non-removable vs. removable devices, knee-high vs. ankle-high boots, therapeutic footwear, and adjunctive surgeries). Current challenges, such as patient adherence, frailty, and balance, are linked to technological responses like smart insoles, remote monitoring, and gamification strategies. Through this historical and evidence-based lens, we highlight how decades-old biomechanical principles are being reimagined with 21st-century innovations, aiming to improve healing rates and patient engagement in DFU care.

Keywords: offloading; diabetic foot ulcer; total contact casting; SmartBoot technologies; limb preservation; mechanical unloading

1. Introduction

Relieving pressure from a wound—the essence of offloading—is as old as medicine itself. Yet applying this principle to the insensate diabetic foot has a distinct history rooted in the management of Hansen's disease (leprosy) and later adapted for diabetes. While our biological understanding of wound healing has advanced, the mechanical necessity of redistributing force remains unchanged [1–3]. As one adage in diabetic foot care goes, "*It's not what you put on, but what you take off*", emphasizing that removing pressure is paramount. Over the past century, offloading techniques have continually evolved, shaped by pioneers and clinical evidence across key eras. This review follows that chronology—from the plaster casts of the 1930s, through the development of TCC as the gold standard in the mid-20th century, to the surge of clinical trials around the millennium, and into today's era of smart technology (Figure 1). We also connect the historical context to contemporary challenges: for example, how an aging patient population with reduced mobility and balance affects offloading strategy, and how modern technology is responding to the perennial issue of

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adherence. Ultimately, understanding where current practices came from—"from plaster to pixels"—can inform better utilization of offloading in clinical practice today [4–6].

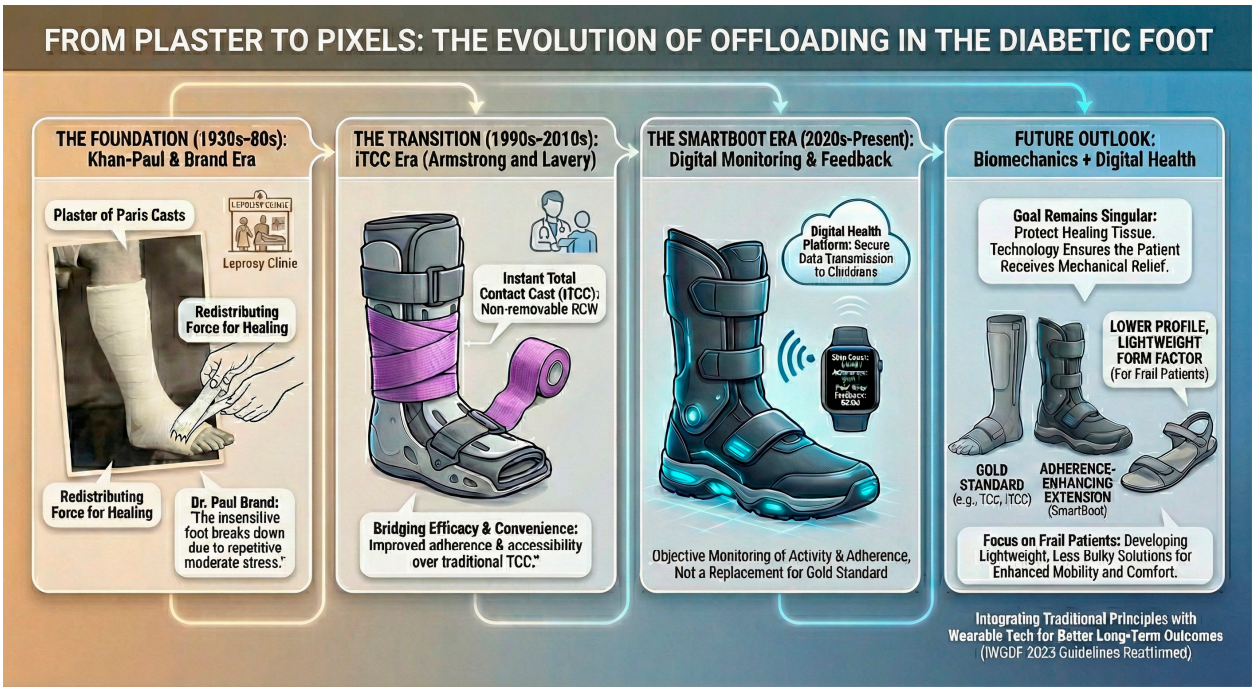


Figure 1. A timeline of offloading over the past century.

2. Methods

This narrative review synthesizes historical and contemporary literature. While a structured search of PubMed and Google Scholar was performed to identify key milestones and evidence, the manuscript is intended as a conceptual synthesis rather than a formal systematic review or meta-analysis.

2.1. The Foundation: The Khan–Paul Era (1930s)

The origins of modern offloading are often traced to the work of Dr. Joseph Khan and Dr. Milroy Paul in the 1930s. Working in India and Ceylon (now Sri Lanka) respectively, these physicians pioneered the use of plaster-of-Paris casts to encase the foot and lower leg, allowing patients with plantar ulcers to remain ambulatory while healing. In 1939, Khan [7] reported treating plantar ulcers in leprosy patients with plaster casts, demonstrating that immobilization and pressure redistribution could heal chronic wounds even in insensate feet. Paul's work in the 1940s further supported casting as a practical therapy in resource-limited settings; his experiences were later quoted by Cochrane in a leprosy textbook, underscoring the early recognition of offloading's efficacy [8].

These early efforts, born in leprosy sanatoriums, established proof-of-concept for offloading: taking weight off an ulcerated foot could facilitate healing even when neuropathy prevented protective pain sensation. It was a revolutionary insight for its time. However, the idea remained relatively isolated to leprosy care and did not immediately permeate mainstream diabetes care. The materials and methods—using heavy plaster casts—were rudimentary by today's standards, yet the Khan-Paul era laid the groundwork by answering a crucial question: *Could offloading heal a neuropathic ulcer?* The answer was yes, and this set the stage for further innovation.

2.2. The Brand Era (1950s–1980s)

Dr. Paul Brand, a legendary figure in both leprosy and diabetic foot care, built upon those early casting techniques and refined them into what we now know as the Total Contact Cast. In the 1950s and 60s, working at the Christian Medical College in Vellore, India, and later at the U.S. Public Health Service Hospital in Carville, Louisiana, Brand recognized that the "insensitive foot" developed ulcers not primarily due to infection or vascular issues, but because of repetitive moderate stress on weight-bearing areas. He emphasized that even without pain, repeated pressure breaks down tissue. To address this, Brand's TCC technique involved molding a well-fitted plaster cast that closely conforms to the contours of the foot and lower leg, redistributing plantar pressure over a broad area. Essentially, the leg is turned into a firm weight-bearing cone, so that pressure is borne by the cast walls rather than the ulcerated sole. This intimate contact (hence "total contact") avoids focal high-pressure points and minimizes shear forces, while the rigidity of the cast immobilizes the ankle and foot to prevent repetitive trauma.

Brand's teachings and publications in the 1960s–1980s cemented the TCC as an ideal offloading modality [1,2,9–11]. By the early 1980s, he and colleagues had demonstrated dramatic healing rates in neuropathic ulcers using TCC, far superior to conventional dressings or footwear of the time. The TCC became known as the "gold standard" for offloading plantar DFUs, a status it largely retains to this day. Indeed, its effectiveness was so clear that for many years, comparisons between new offloading methods and TCC have been a benchmark in research. However, widespread adoption of TCC in routine diabetes care lagged. Applying a proper TCC is labor-intensive and requires skill; additionally, patients must accommodate weeks of living in a cast [12,13]. These practical barriers meant that through the 1980s, TCC use was mostly limited to specialized centers, even as its reputation grew. The Brand era's contribution is monumental: it provided the field with a highly effective tool and a biomechanical explanation for neuropathic ulceration (repetitive stress on an insensate foot), setting a high bar for subsequent innovations to match.

2.3. The iTCC/TCC RCT Era (1990s–2010s)

Despite TCC's proven efficacy, by the 1990s, it was evident that TCC was underutilized in practice [14]. Barriers such as the time and expertise needed for casting, costs, and patient inconvenience led many clinicians to favor more user-friendly removable devices like the prefab pneumatic walking braces (often called removable cast walkers, or RCWs). Research in the late 1990s and early 2000s, led by investigators like Dr. David Armstrong, Lawrence Lavery, and others, focused on bridging the gap between TCC's gold-standard outcomes and the realities of clinical practice. A critical realization was that *adherence* to offloading was just as important as the offloading itself. Removable boots effectively offload pressure when worn, but patients often do not wear them consistently—whether due to discomfort, inconvenience, or misunderstanding. In one study, patients wore their prescribed removable boot only about 28% of the time on average, severely limiting its benefit. This low compliance with removable devices emerged as a primary reason for inferior healing outcomes compared to non-removable casts.

To tackle this, Armstrong and colleagues proposed the "Instant Total Contact Cast" (iTCC)—essentially taking a removable cast walker and rendering it irremovable by wrapping it with a cohesive bandage or plaster strips [15,16]. This simple innovation forced patient adherence by physically preventing the device's removal between clinic visits. Clinical trials in the 2000s confirmed that the iTCC achieved healing rates comparable to traditional TCC. In other words, when a knee-high offloading boot was made non-removable, patient outcomes improved dramatically—not because the device offloaded any better than before, but because it was finally worn near-continuously as intended.

These randomized controlled trials (RCTs) and cohort studies throughout the 1990s–2010s built a strong evidence base favoring non-removable offloading. Comparative trials consistently showed TCC or iTCC healing ~80–90% of neuropathic plantar ulcers in ~6–8 weeks, whereas removable devices (RCWs) left to patient discretion yielded significantly lower healing rates [17,18].

By the 2010s, enough high-quality studies had accumulated to support meta-analyses and inform international guidelines. A recent systematic review and meta-analysis by Lazzarini, Bus, Armstrong et al. synthesized data from 47 controlled studies (including 35 pooled analyses) on offloading interventions [19]. These data are illustrated in Table 1. **Key findings from this meta-analysis include:**

- **Non-removable knee-high devices vs. removable:** Non-removable offloading devices (TCC or iTCC) significantly increased the proportion of DFUs healed compared to removable devices (risk ratio ~1.24, 95% CI 1.09–1.41). In practical terms, making a device non-removable yielded roughly 24% more ulcers healed. Non-removable devices also likely improve patient adherence (since the device is always on) and were associated with fewer infections and better cost-effectiveness, albeit at the cost of more frequent new skin lesions from the device. This underscores the trade-off: enforcing adherence improves healing, but prolonged casting can cause mild skin breakdown elsewhere if not carefully managed.
- **Knee-high vs. ankle-high removable devices:** Surprisingly, removable knee-high boots showed *no significant difference* in healing rates compared to removable ankle-high offloading devices (RR ~1.00, 95% CI 0.86–1.16). The knee-high walkers reduce plantar pressure more than ankle-high walkers, but they also tend to reduce patient adherence (likely due to being bulkier and more cumbersome). Thus, the advantages of better offloading in a taller device may be offset by patients wearing them less. This finding suggests that in real-world use, a device's effectiveness must consider both its biomechanical offloading capacity and the patient's willingness or ability to use it consistently.
- **Any offloading device vs. therapeutic footwear:** Using any dedicated offloading device (casts, boots, etc.) was more effective than just using therapeutic shoes or insoles for healing ulcers. Pooled data showed a trend toward higher healing with offloading devices (RR ~1.39 vs. footwear), although the confidence interval crossed 1.0 in that analysis. Dedicated devices also tended to reduce plantar pressures and infection rates compared to standard diabetic footwear. In practice, this reinforces that while good shoes are critical for prevention, an active ulcer generally requires a purpose-built offloading device for optimal healing.
- **Adjunctive surgical offloading procedures:** The meta-analysis also evaluated interventions like Achilles tendon lengthening and digital flexor tenotomies (often used for recurrent forefoot or toe ulcers). For toe ulcers, adding flexor tenotomy to standard offloading significantly improved healing (one RCT showed RR 2.43, 95% CI 1.05–5.59), presumably by permanently reducing clawing and pressure on the toe apex [20]. For Achilles tendon lengthening aimed at reducing forefoot pressure, evidence suggested a modest increase in healing (RR ~1.10, CI 0.97–1.27)—a trend favoring surgery, though not definitive—and noted a potential trade-off of causing new ulcers at the heel due to altered gait. These surgical approaches can be "force multipliers" for offloading in select patients (e.g., recurrent ulcers due to rigid deformities), but they carry surgical risks and are reserved for specific cases [21].

Overall, the evidence solidly confirmed TCC (or iTCC) as the most effective offloading method for neuropathic plantar DFUs. These findings were foundational to updated international guidelines. The 2023 International Working Group on the Diabetic Foot

(IWGDF) offloading guideline reaffirms that a non-removable knee-high device should be first-line treatment for an uncomplicated plantar DFU, given its superior healing outcomes. If a TCC is not feasible, a removable knee-high walker is the next choice, with the important caveat that every effort should be made to improve patient adherence to it. The evidence that ankle-high devices are less effective primarily due to suboptimal offloading has tilted recommendations toward knee-high devices whenever possible, except in patients who absolutely cannot tolerate them [22].

Table 1. Comparative Offloading Modalities for Plantar DFUs: The following table summarizes key offloading approaches and their effectiveness, highlighting the historical progression from traditional casts to modern devices and the trade-offs in adherence and outcomes.

Off-Loading Modality	Key Features and Usage	Comparative Effectiveness & Considerations
Total Contact Cast (TCC) *Non-removable knee-high cast*	Custom-molded full cast encompassing foot and lower leg; changed ~weekly. Patient cannot remove.	Highest healing efficacy. Gold standard offloading; evenly distributes pressure and enforces near-100% adherence. Healing rates ~30–40% higher than removable. Requires specialized skill to apply; can cause new device-related lesions (e.g., skin rubs) in up to ~1 in 6 patients. Patient convenience and hygiene are challenges.
Instant TCC (iTCC) *Non-removable RCW*	Prefabricated walker boot rendered irremovable by wrap (casting tape or cohesive bandage).	Near-equivalent to TCC in healing. Simplifies application (no casting expertise needed) while forcing adherence like a TCC. Studies show iTCC heals ulcers significantly faster than a boot-worn removable. Shares the same limitations as TCC (patient cannot remove), though application is quicker. Widely adopted in centers aiming to improve outcomes without full casting.
Removable Cast Walker (RCW) *Knee-high removable boot*	Common offloading boots (rigid shell, rocker bottom) reaching just below knee; patient can remove for sleeping, bathing, etc.	Effective pressure relief when worn, but usage often poor. In trials, RCWs offload pressure nearly and TCC biomechanically, but patients often wear them inconsistently (average ~28% of daily steps in one study) [23]. Consequently, healing rates lag behind non-removable devices. Considered second-line if TCC/iTCC not possible, and only effective with strong adherence support.
Ankle-high Offloading Boots *Half-shoes, ankle braces*	Shorter offloading devices (e.g., healing sandal, forefoot offloading shoe, controlled ankle motion boot) not extending to knee.	Lower offloading intensity, but higher tolerance. Easier for patients to ambulate with, improving wear time relative to bulkier boots. RCT evidence found no significant difference in healing vs. knee-high removable boots, suggesting any offloading advantage of knee-high boots may be negated by worse adherence. Still, ankle-high devices generally do not reduce plantar pressure as much, so they are best reserved for patients who absolutely cannot use knee-high devices.
Therapeutic Footwear *Custom diabetic shoes, insoles*	Prescription diabetic shoes, custom insoles, or temporary sandal devices (often used for ulcer prevention or in less severe wounds).	Minimal healing benefit for active ulcers. While specialized footwear is crucial for preventing ulcers and protecting high-risk feet, it provides much less pressure relief than offloading devices. Studies indicate dedicated offloading devices trend toward higher healing rates than footwear alone (RR ~1.4). Thus, footwear alone is usually inadequate for treating a moderate-to-severe plantar ulcer, but it may be used when no other option is feasible (or in conjunction with other measures).

Table 1. *Cont.*

Off-Loading Modality	Key Features and Usage	Comparative Effectiveness & Considerations
Smart Offloading "Boot" *Removable sensor-enabled boot*	New concept: a removable cast boot (often knee or mid-calf) integrated with sensors (inertial measurement unit, pressure sensors) plus a patient-facing app/interface. Provides real-time feedback and reminders.	Emerging approach—aims to improve adherence rather than raw offloading ability. Early systems (SmartBoot) include an IMU sensor that detects when the boot is on vs. off and sends alerts (e.g., vibration or smartphone notification) when the patient is walking without the boot. Gamified elements (like a "happy face" on a smartwatch when the boot is worn, and sad face when not) are used to encourage use. Data (step counts, weight-bearing time, gait metrics) stream to the cloud, allowing the care team to monitor adherence and mobility remotely. Clinical efficacy: Still being studied; early trials show improved compliance and patient satisfaction, but these devices should be seen as facilitating proper offloading use, not a replacement for the TCC in sheer pressure relief.

(Abbreviations: DFU = diabetic foot ulcer; RCT = randomized controlled trial; RR = risk ratio; IMU = inertial measurement unit.)

Yet, this era also taught us that one size does not fit all. Real-world utilization of TCC remained low; surveys have indicated that many wound centers seldom use TCC, citing practicality and patient factors. Some patients (especially older, frail individuals) may be unable to safely ambulate in a knee-high cast or might refuse it. Indeed, as people are living longer with diabetes complications, clinicians are encountering more patients with limited mobility or balance problems that make traditional casts or walkers difficult to use. For instance, very elderly patients or those with gait instability face a heightened fall risk when wearing a bulky cast. In such cases, practitioners sometimes resort to compromises like offloading half-shoes, healing sandals, or wheelchair offloading, accepting a possibly longer healing time in exchange for safety. The RCT era highlighted the critical interplay between raw offloading power and human factors (adherence, comfort, safety). This set the stage for a new wave of innovation aiming to maximize offloading efficacy while also maximizing patient engagement and adherence—essentially, to get as close as possible to the outcomes of a TCC *without* the downsides of forcing a patient into a cast [24].

2.4. The SmartBoot Era (2020s–2025)

We are now entering an era where offloading is augmented by wearable technology and digital health platforms—essentially moving "from plaster to pixels." The goal remains the same as in Khan's or Brand's time (protect the wounded foot from pressure), but the approach is evolving to address the human factors that have long challenged offloading therapy, especially adherence. Several converging trends define this SmartBoot era:

Wearable Sensors for Monitoring Offloading: Researchers have developed sensor-enabled insoles and boots that can objectively measure pressure or usage. For example, pressure-sensing smart insoles can detect when excessive plantar pressure is occurring and alert the patient to offload that foot. One proof-of-concept trial demonstrated that such pressure-feedback insoles reduced the 18-month incidence of DFUs by 71% compared to controls, presumably by "replacing" the lost pain feedback with an alert system. Another simple but powerful tool has been the Orthotimer device, which tracks how many hours a day a custom insert or boot is worn, helping quantify adherence (studies show a strong correlation between wear time and healing outcomes). By 2020, sensor research had expanded to include remote temperature monitors (to catch inflammation early) and even smart socks. Each of these addresses a piece of the puzzle: pressure, adherence, or early warning signs. Notably, a review highlighted the potential of sensors, wearables, and telehealth for remote management of high-risk feet. In essence, sensors are enabling what

one group called the "Internet of Medical Things" for the diabetic foot—instrumenting the foot and footwear to continuously measure parameters important for ulcer prevention and healing [25].

The SmartBoot Concept—Integrating Offloading with Digital Health: Among the most ambitious developments is the SmartBoot system, first introduced in the early part of the 2020s [26–28]. The SmartBoot is essentially a traditional removable offloading boot enhanced with an embedded inertial sensor and a Bluetooth-connected smartwatch or smartphone interface. The sensor detects whether the boot is being worn and tracks patient activity (steps, standing time, gait cadence). Data is transmitted in real-time to the patient's device and securely to cloud servers. The novelty lies in the feedback loop: patients receive immediate alerts and motivational feedback about their offloading adherence. For example, if a patient starts walking without the boot, the SmartBoot system can send an alert—vibration or sound—reminding them to put it on. One implementation even uses an emotive visual indicator: a simple smiling face displays on the smartwatch when the boot is worn during weight-bearing, turning into a sad face when the patient is walking unprotected [27]. This gamification element taps into behavioral psychology, making adherence a more engaging, immediate goal. Instead of the patient only hearing from their doctor at weekly visits that they did not wear their boot enough, the SmartBoot provides continuous "nudges" toward the desired behavior.

On the clinician side, these systems create new streams of data. A treating clinician can remotely monitor how much a patient is walking, how often and how long the offloading device is worn, and even gait parameters like cadence and balance that correlate with fall risk or frailty. Dashboards have been envisioned where a provider can see, for example, that a patient's daily step count tripled on days they left the boot off, or that their cadence (walking speed) is abnormally slow, potentially indicating a balance issue or worsening frailty. Early studies suggest this data-driven approach allows for personalized interventions—e.g., targeted education for a patient who is not wearing the boot at home or switching an elderly patient to a different device if their gait stability in the boot is poor. Importantly, the aim of SmartBoot is not to replace the TCC (non-removable cast) in scenarios where that is feasible, but to dramatically improve the outcomes in all the scenarios where a removable device is used in practice. In other words, it is an adherence augmentation tool to get patients as close as possible to the ideal offloading regimen.

Real-world deployment of such smart offloading is still in early stages, but initial results have been promising. Patients across diverse age groups found the smart feedback approach acceptable and even motivating [27,28]. This is critical, as any new technology is only useful if patients are willing to use it. One qualitative outcome has been a shift in philosophy—from doing offloading "to" the patient (as with a forced TCC) to doing it "with" the patient. Armstrong noted that while non-removable casting healed wounds, it felt punitive to some patients (being cast against their will) [29]. The SmartBoot, by contrast, gives patients autonomy (they can remove it if truly needed) but holds them accountable through gentle, constant reminders and involvement in their own data.

Other Digital Health Integrations: Beyond the SmartBoot itself, the 2020s have seen a surge in digital health tools for DFU care in general. Telemedicine became more common during the COVID-19 pandemic, leading to experiments in remote monitoring of wounds and offloading. Patients can now send photos of their ulcers, while wearables send activity data, allowing virtual adjustments to treatment plans. Smartphone apps have been piloted that employ gamification and incentives for foot care adherence. For example, some apps give users points or rewards for each day they meet a step count goal with the offloading boot on, or they display progress bars/achievements for keeping pressure off the foot [24,25]. The underlying idea is to leverage the same techniques that get people addicted

to checking their fitness tracker or mobile games—but in service of medical adherence. Early evidence suggests these approaches can modestly improve patient engagement, though long-term impact on ulcer healing or prevention is still under investigation.

Notably, smart offloading technologies are also tackling issues like balance and fall risk. Some sensor-enabled boots can track sway or gait stability, potentially alerting if a patient is at risk of falling while using the device. Others incorporate features to improve balance, such as optimally designed rocker soles or even microfluidic inserts that adjust stance. Furthermore, as frailty has emerged as a strong predictor of poor DFU outcomes (frail patients are less likely to heal and more likely to suffer complications) [30], there is interest in integrating frailty assessments into DFU management. For instance, cadence (walking speed) measured by a SmartBoot can serve as a surrogate for a patient's physical frailty—very slow gait might prompt a clinician to involve physical therapy or use a different offloading approach for safety. In this way, the modern offloading paradigm is becoming more holistic: not just focusing on the foot in isolation, but on the patient's overall ability to adhere and ambulate safely. To put it another way, as people live longer with complications of diabetes as they are now, we are seeing a paradox of reduced functional capacity even in patients entering middle age and older adults. This makes traditional knee-level offloading less feasible, requiring us to look toward other compromises such as healing sandals [30].

In summary, the current SmartBoot era is characterized by a fusion of traditional biomechanics with digital monitoring and behavioral science. We have "smarter" boots and insoles that not only offload pressure but also record whether they are being used and actively encourage patients to use them. Table 1 illustrates how these new devices compare conceptually to traditional methods. It is an exciting frontier, but one must also acknowledge that the core principle has not changed: we still need to relieve pressure to heal the ulcer. Technology is an enabler, ensuring that relief happens in the day-to-day life of the patient. Early trials of smart offloading systems are ongoing, and in the coming years, we will learn whether features like real-time adherence monitoring can translate into significantly improved healing rates or reduced recurrence. If they do, future guidelines may formally incorporate smart devices as part of standard care. Even if not, the knowledge gained about patient behavior and pressure exposure in real life will be invaluable.

2.5. Implementation Challenges and the Digital Divide

Despite the promise of 'pixels,' significant barriers to real-world implementation remain. The cost of sensor-integrated systems may limit their use to well-funded healthcare systems, potentially widening the health equity gap. Furthermore, the digital divide remains a reality; elderly patients—the demographic most at risk for DFUs—may struggle with app interfaces or lack the necessary hardware, requiring 'low-tech' alternatives that still respect biomechanical principles.

3. Conclusions

From the early plaster casts applied by Khan and Paul in the 1930s to the intelligent sensor-laden boots of today, the goal of offloading in diabetic foot care remains the same: protect the healing tissue from the trauma of daily weight-bearing. Over nearly a century, materials have shifted from gypsum to fiberglass to high-tech polymers, and now to microchips and data streams—yet the fundamental lesson endures. Technology does not replace the need for mechanical pressure relief; rather, it enhances our ability to ensure that the patient actually receives that relief consistently. Non-removable casting showed that healing is achievable if we can guarantee adherence. Modern innovations are finding new ways to guarantee adherence not by force, but by information, feedback, and engagement. In a way, we are coming full circle: earlier eras taught us "what" to do (off-load the foot) and

"how" to do it (TCC, boots, etc.), whereas the current era is teaching us how to help patients *want to do it*. As we stand on the threshold of integrating digital health with time-tested principles, the hope is that we can finally close the gap between what is biomechanically optimal and what is practically achievable for each individual patient. By uniting plaster's wisdom with pixels' intelligence, the next generation of offloading strategies may achieve outcomes once thought out of reach—healing more ulcers, preventing more amputations, and empowering patients as active partners in their limb preservation.

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References

1. Brand, P.W. The insensitive foot (including leprosy). In *Disorders of the Foot*; Jahss, M.H., Ed.; WB Saunders: Philadelphia, PA, USA, 1982; pp. 217–219.
2. Bauman, J.; Girling, J.; Brand, P. Plantar pressures and trophic ulceration. *J. Bone Jt. Surg. Br. Vol.* **1963**, *45B*, 652–673. [CrossRef]
3. Bauman, J.H.; Brand, P.W. Measurement of pressure between foot and shoe. *Lancet* **1963**, *1*, 629–632. [CrossRef] [PubMed]
4. Armstrong, D.G.; Lavery, L.A.; Nixon, B.P.; Boulton, A.J.M. It's not what you put on, but what you take off: Techniques for debriding and offloading the diabetic foot wound. *Clin. Infect. Dis.* **2004**, *39*, S92–S99. [CrossRef] [PubMed]
5. Armstrong, D.G.; Tan, T.W.; Boulton, A.J.M.; Bus, S.A. Diabetic Foot Ulcers A Review. *JAMA* **2023**, *330*, 62–75. [CrossRef] [PubMed]
6. Wu, Y.; Chen, Y.; Wang, H.; Dong, S.; Yan, H.O.; Xie, J. Comparison of the effectiveness and safety of different non-surgical offloading interventions for diabetic foot ulcers: A network meta-analysis of randomized controlled trials. *Int. J. Low. Extrem. Wounds* **2025**, 15347346251329608. [CrossRef]
7. Khan, J. Treatment of plantar ulcers in leprosy with plaster of Paris. *Lepr. Rev.* **1939**, *10*, 15–18.
8. Paul, M.A. *Quoted in: Practical Textbook of Leprosy*; Cochrane, R., Ed.; Oxford University Press: Oxford, UK, 1947.
9. Boulton, A.J.M. Diabetic foot—what can we learn from leprosy? Legacy of Dr Paul W. Brand: Diabetic Foot: Legacy of Dr Paul W. Brand. *Diabetes Metab. Res. Rev.* **2012**, *28*, 3–7. [CrossRef]
10. Brand, P.W. The Diabetic Foot. In *Diabetes Mellitus: Theory and Practice*; Ellenberg, M.R.H., Ed.; Medical Examination Publishing Co., Inc.: Flushing, NY, USA, 1984; pp. 829–849.
11. Coleman, W.C.; Brand, P.W.; Birke, J.A. The total contact cast. A therapy for plantar ulceration on insensitive feet. *J. Am. Podiatry Assoc.* **1984**, *74*, 548–552. [CrossRef]
12. Gauna, C.; Romeo, F.; Scatena, A.; Miranda, C.; Uccioli, L.; Vermigli, C.; Volpe, A.; Bordieri, C.; Tramonta, R.; Ragghianti, B.; et al. Offloading systems for the treatment of neuropathic foot ulcers in patients with diabetes mellitus: A meta-analysis of randomized controlled trials for the development of the Italian guidelines for the treatment of diabetic foot syndrome. *Acta Diabetol.* **2024**, *61*, 693–703. [CrossRef]
13. Ganguly, S.; Chakraborty, K.; Mandal, P.K.; Ballav, A.; Choudhury, S.; Bagchi, S.; Mukherjee, S. A comparative study between total contact casting and conventional dressings in the non-surgical management of diabetic plantar foot ulcers. *J. Indian Med. Assoc.* **2008**, *106*, 237–239, 244.
14. Ludwig, K.; Homer, V.; Jensen, J. Ease of Application and Removal of Common Total-Contact Cast Systems Used in the Podiatric Medical Community. *J. Am. Podiatr. Med. Assoc.* **2019**, *109*, 445–450. [CrossRef]
15. Armstrong, D.G.; Short, B.; Espensen, E.H.; Abu-Rumman, P.L.; Nixon, B.P.; Boulton, A.J.M. Technique for fabrication of an "instant total-contact cast" for treatment of neuropathic diabetic foot ulcers. *J. Am. Podiatr. Med. Assoc.* **2002**, *92*, 405–408. [CrossRef] [PubMed]

16. Armstrong, D.G.; Lavery, L.A.; Wu, S.; Boulton, A.J.M. Evaluation of removable and irremovable cast walkers in the healing of diabetic foot wounds: A randomized controlled trial. *Diabetes Care* **2005**, *28*, 551–554. [CrossRef] [PubMed]
17. Katz, I.A.; Harlan, A.; Miranda-Palma, B.; Prieto-Sanchez, L.; Armstrong, D.G.; Bowker, J.H.; Mizel, M.S.; Boulton, A.J. A randomized trial of two irremovable offloading devices in the management of plantar neuropathic diabetic foot ulcers. *Diabetes Care* **2005**, *28*, 555–559. [CrossRef] [PubMed]
18. Armstrong, D.G.; Nguyen, H.C.; Lavery, L.A.; Van Schie, C.H.; Boulton, A.J.M.; Harkless, L.B. Offloading the diabetic foot wound: A randomized clinical trial (Abstract). *Diabetes Care* **2001**, *24*, 1019–1022. [CrossRef]
19. Lazzarini, P.A.; Armstrong, D.G.; Crews, R.T.; Gooday, C.; Jarl, G.; Kirketerp-Moller, K.; Viswanathan, V.; Bus, S.A. Effectiveness of offloading interventions for people with diabetes-related foot ulcers: A systematic review and meta-analysis. *Diabetes Metab. Res. Rev.* **2023**, *40*, e3650. [CrossRef]
20. Andersen, J.A.; Rasmussen, A.; Engberg, S.; Bencke, J.; Frimodt-Møller, M.; Kirketerp-Møller, K.; Rossing, P. Flexor Tendon Tenotomy Treatment of the Diabetic Foot: A Multicenter Randomized Controlled Trial. *Diabetes Care* **2022**, *45*, 2492–2500. [CrossRef]
21. Frykberg, R.G.; Attinger, C.; Smeets, L.; Koller, A.; Bal, A.; Kavarthapu, V. Surgical strategies for prevention of amputation of the diabetic foot. *J. Clin. Orthop. Trauma* **2021**, *17*, 99–105. [CrossRef]
22. Bus, S.A.; Armstrong, D.G.; Crews, R.T.; Gooday, C.; Jarl, G.; Kirketerp-Moller, K.; Viswanathan, V.; Lazzarini, P.A. Guidelines on offloading foot ulcers in persons with diabetes (IWGDF 2023 update). *Diabetes Metab Res Rev.* **2023**, *40*, e3647. [CrossRef]
23. Armstrong, D.G.; Lavery, L.A.; Kimbriel, H.R.; Nixon, B.P.; Boulton, A.J.M. Activity patterns of patients with diabetic foot ulceration: Patients with active ulceration may not adhere to a standard pressure offloading regimen. *Diabetes Care* **2003**, *26*, 2595–2597. [CrossRef]
24. Najafi, B.; Mishra, R. Harnessing Digital Health Technologies to Remotely Manage Diabetic Foot Syndrome: A Narrative Review. *Medicina* **2021**, *57*, 377. [CrossRef]
25. Bus, S.A.; Reeves, N.D.; Armstrong, D.G.; Najafi, B. Offloading and adherence through technological advancements: Modern approaches for better foot care in diabetes. *Diabetes Metab. Res. Rev.* **2024**, *40*, e3769. [CrossRef] [PubMed]
26. Park, C.; Mishra, R.; Vigano, D.; Macagno, M.; Rossotti, S.; D'hUyvetter, K.; Garcia, J.; Armstrong, D.G.; Najafi, B. Smart Offloading Boot System for Remote Patient Monitoring: Toward Adherence Reinforcement and Proper Physical Activity Prescription for Diabetic Foot Ulcer Patients. *J. Diabetes Sci. Technol.* **2022**, *17*, 42–51. [CrossRef] [PubMed]
27. Cay, G.; Lee, M.; Armstrong, D.G.; Najafi, B. SmartBoot: Real-time monitoring of patient activity via remote edge computing technologies. *Sensors* **2025**, *25*, 4490. [CrossRef] [PubMed]
28. Finco, M.G.; Cay, G.; Lee, M.; Garcia, J.; Salazar, E.; Tan, T.-W.; Armstrong, D.G.; Najafi, B. Taking a load off: User perceptions of smart offloading walkers for diabetic foot ulcers using the Technology Acceptance Model. *Sensors* **2023**, *23*, 2768. [CrossRef]
29. Faye, K. Researchers Publish First Successful "Smart Boot" Study Regarding Diabetes-Related Wounds—HSC News. HSC News—News for USC's Health Sciences Campus Community. Available online: https://hscnews.usc.edu/researchers-publish-first-successful-smart-boot-study-regarding-diabetes-related-wounds (accessed on 18 December 2025).
30. Hong, A.T.; Luu, I.Y.; Deras-Guerra, B.; Han, S.; Shin, L.; Shih, C.-D.; Armstrong, D.G.; Tan, T.-W. Association between frailty progression and clinical outcomes in patients with diabetic foot ulcers. *Surgery* **2025**, *186*, 109599. [CrossRef]

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