Opis przypadku *Case report*

Adaptive fibular hypertrophy consistent with Wolff's law following persistent tibial non-union in a cat: A case report*

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Summary

Aim. The aim of this study was to present the case of a cat with persistent tibial non-union in which progressive, spontaneous fibular hypertrophy was observed during a three-year radiographic follow-up.

Material and methods. An approximately 2-year-old domestic shorthair cat with an open, comminuted, non-reconstructable fracture of the left tibia and fibula after a fall from height was described. Stabilization was performed using an intramedullary Kirschner wire and a bridging locking compression plate. Following wound complications and infection, the plate was removed and the intramedullary wire was retained. Serial radiographs in craniocaudal and mediolateral projections were obtained over 32.8 months, and the transverse diameter of the fibula was measured at the same anatomical level using vPOP PRO software.

Results. Despite persistent tibial non-union, the fibular diameter increased from 1.75 mm to 6.30 mm, corresponding to an increase of approximately 260% in the craniocaudal projection and 318.8% in the mediolateral projection. Hypertrophy was most pronounced during the first 7.5 months of follow-up. On subjective clinical assessment the cat appeared to bear weight on the affected limb without overt lameness; however, no standardized lameness scoring, goniometry, force-plate analysis, or owner-reported outcome measure was used, and this apparent preservation of function should be interpreted with caution.

Conclusions. The observed fibular hypertrophy is consistent with Wolff's law and represents an example of adaptive bone remodeling in response to chronically altered mechanical loading. This phenomenon should not be regarded as an alternative to standard reconstructive treatment of non-union but rather as a possible compensatory mechanism warranting further clinical documentation.

Keywords: Wolff's law, tibial non-union, fibular hypertrophy, tibialization

Tibial fractures are relatively common orthopedic injuries in cats and represent a clinical challenge because of limited soft tissue coverage, specific vascular supply, and the important role of mechanical stability in the healing process (36). The major complications associated with the treatment of tibial fractures include delayed union and non-union, particularly in open, comminuted, infected fractures or those associated with bone fragment loss (4, 10, 19).

Various stabilization methods have been described for the treatment of tibial fractures in cats, including open reduction and internal fixation with plates and screws, external fixation, low-stiffness fixators, circular fixators, and minimally invasive plate osteosynthesis (9, 31). The choice of technique depends on the location and configuration of the fracture, the degree of soft tissue damage, the presence of contamination or infection, the possibility of achieving mechanical stability, and the preservation of biological conditions for healing (4, 12, 36). In comminuted or biologically unfavorable fractures, increasing importance is attributed to the principles of biological osteosynthesis, which aim to minimize additional damage to soft tissues and vascular supply while providing sufficient

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stabilization (5, 23). In cases complicated by non-union or large bone defects, revision treatment may be necessary, including restabilization, bone grafting, or other reconstructive techniques (16, 19).

Wolff's law describes the capacity of bone to adapt its internal structure and external morphology in response to the direction and magnitude of mechanical loading (8, 29, 30). Increased and repetitive loading may stimulate bone formation, resulting in increased bone mass, cortical thickening, and structural remodeling, whereas reduced loading promotes bone resorption and weakening (2, 8, 29). This adaptive response is mediated by mechanotransduction, through which osteocytes detect mechanical strain and regulate bone remodeling (17, 28).

The significance of Wolff's law extends beyond the physiological adaptation of the skeleton to physical activity. This mechanism also plays an important role in fracture healing, callus remodeling, the bone response to orthopedic implants, and long-term adaptation to altered limb biomechanics (8, 18). Particularly interesting are situations in which chronic changes in force distribution lead to remodeling of a bone that did not originally serve the primary weight-bearing function. In such cases, Wolff's law ceases to be merely a theoretical principle of biomechanics and becomes a visible clinical process of bone tissue adaptation to new loading conditions.

Physiologically, the fibula plays a much smaller weight-bearing role than the tibia; however, under conditions of altered biomechanics, it may undergo adaptive remodeling. In human orthopedics, cases of so-called fibular tibialization have been described, in which the fibula, subjected to long-term increased loading, underwent hypertrophy and partially assumed the function of the tibia (6, 15, 26, 27). In small animals, adaptive changes in bone structure have been observed during fracture healing, in response to repetitive physical loading, and following orthopedic procedures that alter limb biomechanics, including tibial plateau leveling osteotomy (32). However, to the authors' knowledge, no long-term veterinary reports have described a comparable degree of progressive fibular hypertrophy in cats with chronic tibial non-union. PubMed, Scopus, and Web of Science were searched using combinations of the keywords "fibular hypertrophy", "fibular remodeling", "fibular tibialization", "feline", and "cat".

The aim of this case report is to describe a cat with persistent tibial non-union following treatment of an open, comminuted fracture of the tibia and fibula, in which progressive spontaneous fibular hypertrophy and preservation of limb function were observed during a three-year radiographic follow-up. This case represents a clinical example of adaptive bone remodeling consistent with Wolff's law and may expand current knowledge of compensatory biomechanical mechanisms in feline patients.

Case description

In September 2023, an approximately 2-year-old domestic shorthair cat weighing 4.2 kg was presented to the 24-hour Veterinary Clinic of the University of Warmia and Mazury in Olsztyn following a fall from height that had occurred five days before admission. On clinical examination, the patient was systemically stable; however, an open fracture of the left pelvic limb was identified. Radiographic examination revealed a severely comminuted fracture of the left tibia and fibula, characterized by numerous small bone fragments and complete disruption of the osseous columns. The fracture was considered non-reconstructable because the fragment size and configuration prevented anatomical reduction and restoration of continuous cortico-medullary alignment (Fig. 1). The patient was hospitalized for stabilization and preparation for surgical treatment. The hair surrounding the wound was widely clipped, and the wound was thoroughly lavaged with sterile physiological saline. Surgical debridement of contaminated and nonviable tissues was subsequently performed. A microbiological sample was not collected because the wound was grossly contaminated and a superficial culture was considered unlikely to reliably identify microorganisms associated with a clinically relevant infection. During hospitalization, fluid therapy was administered, together with analgesic treatment consisting of tramadol at a dose of 2 mg/kg body weight twice daily and robenacoxib at a dose of 2 mg/kg body weight once daily. Antibiotic therapy with clindamycin at a dose of 5.5 mg/kg body weight twice daily was also initiated.

Two days later, after stabilization of the patient's condition, surgical osteosynthesis of the tibia was performed. Because of the nature of the injury – an open fracture that



Fig. 1. Preoperative radiographs of the left pelvic limb obtained in the craniocaudal (A) and mediolateral (B) projections, demonstrating a comminuted, non-reconstructable open fracture of the left tibia and fibula

had been present for seven days – and the owner's decision to decline limb amputation, debridement and freshening of the bone ends were performed instead. The bone was shortened accordingly, as the protruding fragments exposed through the wound showed partial necrotic changes and were therefore not suitable for preservation. The proximal and distal tibial fragments were resected back to viable bone using an oscillating saw, and nonviable bone fragments were removed from the fracture site. A combined intramedullary pin and bridging plate construct was selected to maintain axial alignment, provide load sharing, and stabilize the main proximal and distal fragments without attempting anatomical reconstruction of the severely comminuted fracture zone. Fracture stabilization was performed using a 1.6-mm intramedullary Kirschner wire and a 2.0-mm locking compression plate applied in a bridging configuration, with three locking screws placed in each main bone fragment (Fig. 2). Primary bone grafting was not performed because of the gross wound contamination and the associated risk of infection within the graft and recipient site. The resulting bone defect was left to heal under stable bridging fixation. After surgery, a soft padded Robert Jones bandage was applied for additional support. The immediate postoperative period was uneventful, and the patient began bearing weight on the operated limb on the first day after surgery. Because of the cat's good general condition, it was discharged home on the day after surgery. The owner was instructed to strictly restrict the animal's activity and to continue pharmacological treatment. Postoperative therapy included administration of a non-steroidal anti-inflammatory drug for 7 days, tramadol for 3 days, and continuation of antibiotic therapy for 10 days after surgery.

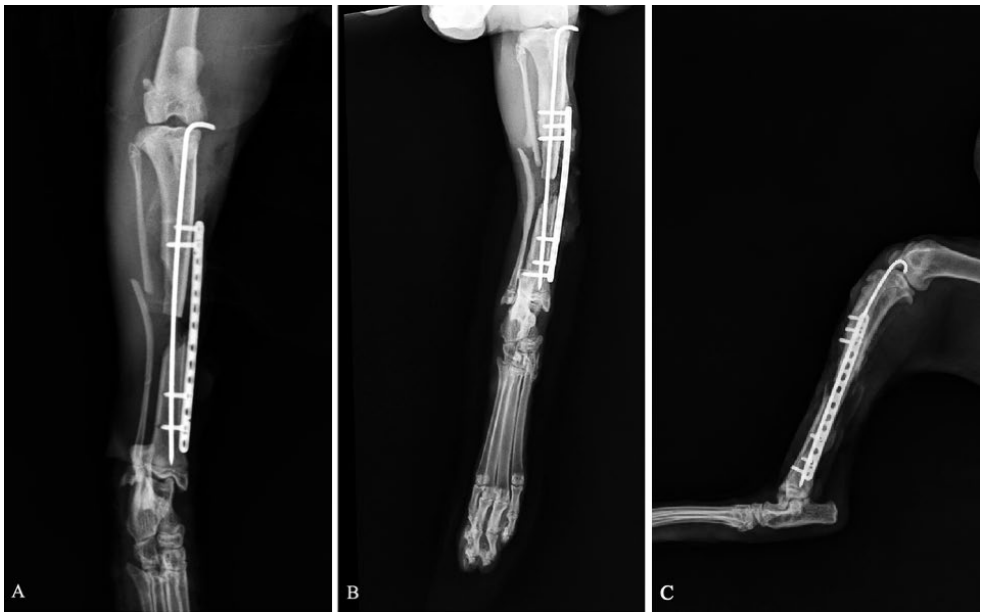


Fig. 2. Radiographic images documenting the course of treatment of the left tibial fracture Explanations: (A) Immediate postoperative radiograph obtained following stabilization with a 1.6-mm intramedullary Kirschner wire and a 2.0 locking compression plate applied in a bridging configuration. (B) Craniocaudal radiograph obtained 2 months after surgery. (C) Mediolateral radiograph obtained 3 months after surgery, demonstrating the absence of radiographic union of the tibia and persistent fracture gap

Four days after surgery, the patient was readmitted to the clinic because of the concerning appearance of the postoperative wound. The cat remained systemically stable and afebrile, and hematological and biochemical test results were within the reference ranges. Clinical examination revealed that the cat had removed most of the skin sutures, resulting in wound dehiscence and exposure of the plate used for fracture stabilization. In addition, purulent wound discharge and necrosis of part of the skin covering the osteosynthesis site were observed. A sample was collected for bacteriological examination and antimicrobial susceptibility testing. Pending the results, local treatment was initiated, consisting of daily wound cleaning and the application of dressings containing silver-ion hydrogel. Three days later, bacteriological examination identified *Staphylococcus pseudintermedius* susceptible to amoxicillin/clavulanic acid. Based on the antimicrobial susceptibility results, targeted antibiotic therapy with amoxicillin/clavulanic acid at a dose of 20 mg/kg body weight was administered for 14 days. Daily wound cleaning and dressing changes with silver-containing dressings were continued. The purulent discharge, tissue necrosis, implant exposure, and positive bacterial culture were consistent with a deep surgical site and implant-associated infection.

Despite regular wound cleaning, dressing changes, and targeted antibiotic therapy, the wound over the plate failed to heal. Follow-up radiographs were obtained periodically at approximately 4-week intervals. Because of the absence of radiographic signs of bone union during the 3-month postoperative period and the persistent problems with skin wound healing, the treatment options were discussed in detail with the owner, including revision osteosynthesis combined with autologous bone grafting, limb amputation, and removal of the exposed plate while retaining the intramedullary Kirschner wire. The owner was fully informed of the expected outcomes and risks associated with each option. Given financial constraints, and considering that the cat was clinically weight-bearing and moving freely despite the absence of radiographic bone union, the owner elected to proceed with plate removal and continued conservative management rather than revision surgery or amputation. This decision was made on the understanding that the cat's comfort and limb use would continue to be closely monitored, and that surgical intervention would be reconsidered without delay if its condition deteriorated. The plate was accordingly removed, while the intramedullary Kirschner wire was retained to provide residual stabilization (Fig. 3). Further monitoring of the healing process was continued, with follow-up radiographic examinations performed at 8- to 9-week intervals.



Fig. 3. Radiographs of the left pelvic limb obtained 6 months after surgery following plate removal
Explanations: Mediolateral (A) and craniocaudal (B) projections reveal persistent tibial non-union with a maintained fracture gap, retention of the intramedullary Kirschner wire, and progressive adaptive hypertrophy of the fibula.

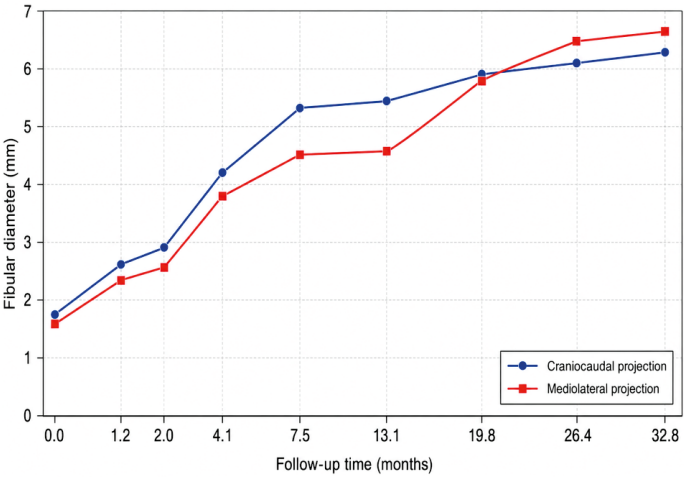


Fig. 4. Serial radiographic measurements of fibular diameter during the 32.8-month follow-up period

All radiographic examinations were performed using the same digital radiography system. The radiographs were obtained in standard craniocaudal and mediolateral projections and saved in DICOM format. Image calibration and all measurements were performed using vPOP PRO software. At each follow-up examination, the total transverse diameter of the fibula was measured at the same anatomical level of the diaphysis in both projections. The measurement line was positioned perpendicular to the longitudinal axis of the fibula and extended between the external cortical margins. All measurements were performed by the same investigator. Each measurement was repeated three times, and the arithmetic mean of the three measurements was used for further analysis and presentation in the table and line chart. Measurements were recorded in millimeters to two decimal places.

During the three-year follow-up period after the initial osteosynthesis, serial radiographic examinations demonstrated progressive hypertrophy and remodeling of the fibula (Fig. 3). The fibular diameter increased from 1.75 mm at the initial examination to 6.30 mm at the three-year follow-up, corresponding to an approximately 260% increase (Tab. 1, Fig. 4).

To facilitate visualization of the temporal pattern of fibular remodeling, serial measurements obtained in both radiographic projections are presented graphically in Figure 4, demonstrating rapid initial hypertrophy followed by slower but continued enlargement.

Despite persistent tibial non-union, the cat voluntarily bore weight on the affected limb, used it during walking, and maintained outdoor access. No obvious lameness was observed during routine clinical examination; however, no standardized lameness score, goniometric range-of-motion assessment, force-plate analysis, or validated owner questionnaire was used. Functional evaluation in this case therefore relied solely on conventional radiography and subjective clinical observation; no computed tomography or histological assessment of the fibula or tibial non-union site was performed, and this represents an important limitation of the case. The radiographic findings suggest adaptive fibular hypertrophy associated with altered mechanical loading. Three years after surgery, the tibia still showed no evidence of bone union (Fig. 5).

Tab. 1. Serial radiographic measurements of fibular diameter during the follow-up period

Examination date	Follow-up (months)	Fibular diameter craniocaudal (mm)	Change from baseline (%)	Fibular diameter mediolateral (mm)	Change from baseline (%)
04.09.2023	0.0	1.75	0.0	1.60	0.0
10.10.2023	1.2	2.60	48.6	2.37	48.1
04.11.2023	2.0	2.90	65.7	2.58	61.3
01.07.2024	4.1	4.20	140.0	3.80	137.5
04.09.2024	7.5	5.32	204.0	4.52	182.5
10.10.2024	13.1	5.45	211.4	4.60	187.5
04.03.2025	19.8	5.90	237.1	5.80	262.5
11.11.2025	26.4	6.10	248.6	6.50	306.3
30.05.2026	32.8	6.30	260.0	6.70	318.8

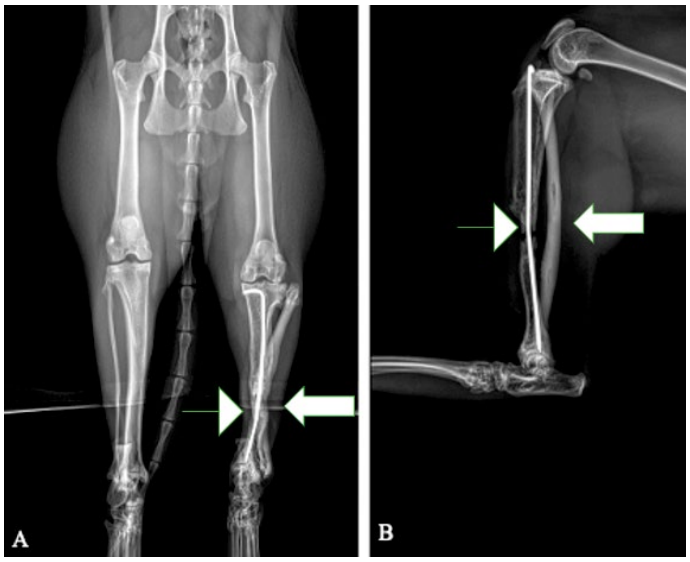


Fig. 5. Radiographs of the left pelvic limb obtained three years after surgery
Explanations: Craniocaudal (A) and mediolateral (B) projections demonstrate persistent tibial non-union, pronounced hypertrophy and remodeling of the fibula (white arrows), and bending of the retained intramedullary Kirschner wire (arrowheads). The fibular changes are compatible with adaptive remodeling in response to increased mechanical loading. The bending of the Kirschner wire suggests prolonged cyclic loading and persistent mechanical instability despite progressive fibular hypertrophy.

Discussion

Tibial fractures in cats are relatively common orthopedic injuries and represent an important clinical problem because this region is predisposed to impaired healing (13, 24). In one retrospective study cohort involving 57 cats with tibial fractures, most injuries affected the tibial diaphysis (24). Of particular clinical importance is the fact that the tibial region is characterized by limited soft tissue coverage, fewer muscular attachments, and specific biomechanical conditions, all of which may adversely affect fracture healing (22, 24).

Complications following surgical stabilization of feline tibial diaphyseal fractures have been reported relatively frequently in selected retrospective case series. In one study cohort, the overall complication rate was 40.4%, with rates of 50.0% following external skeletal fixation and 7.7% following open reduction and internal fixation (24). One of the most important clinical complications is non-union. Non-union rates have also varied between published cohorts. Perry and Bruce reported a rate of 14%, whereas Nolte et al. reported a rate of 15.3% when tibial fractures were considered separately (22, 24). Differences between studies may reflect variations in fracture configuration, soft-tissue injury, contamination, case selection, and fixation technique. Non-union in cats has been observed more frequently in open fractures, comminuted fractures, older and heavier cats, and with certain stabilization methods, particularly rigid type II external skeletal fixators (5).

An important factor predisposing to tibial non-union after osteosynthesis is the nature of the primary injury. Open and comminuted fractures are often accompanied by extensive soft tissue damage, disruption of local vascular supply, wound contamination, and an increased risk of infection (1, 35). Delayed union or non-union may result from both biological factors, such as insufficient vascularization associated with the limited amount of soft tissue surrounding the tibia, and mechanical factors, including inadequate construct stability, an excessive fracture gap, or interposition of soft tissues within the fracture line (21). In the present case, the primary injury was an open, comminuted, non-reconstructable fracture of the tibia and fibula, and the postoperative course was complicated by persistent wound-related problems. In this context, the development of tibial non-union appears biologically justified and consistent with risk factors described in the literature.

Another factor that may influence the development of tibial non-union is the osteosynthesis technique used. The literature emphasizes that the choice of stabilization method should take into account both the fracture configuration and the biological and mechanical conditions at the fracture site. In the study by Perry and Bruce (24), which included cats with tibial diaphyseal fractures, a significantly higher complication rate was demonstrated after the use of external skeletal fixators compared with open reduction and internal fixation. Complications occurred in 50% of cats treated with external fixation, whereas in the ORIF group they were recorded in only 7.7% of patients; moreover, all major complications occurred in cases treated with external skeletal fixators (24). Similar conclusions have been drawn from more recent analyses, which indicate that although direct data comparing internal and external fixation in cats are limited, available reports suggest a higher risk of complications associated with external fixation, particularly in cases requiring intensive postoperative care and those exposed to pin tract infection (3, 11, 13, 34). The importance of stabilization technique is further supported by the study by Witte et al. (33), which described the treatment of distal tibial fractures in cats using a hybrid external skeletal fixator. In a retrospective analysis of eight cases, the authors found that despite appropriate postoperative fracture reduction and the use of external fixation, three patients developed tibial non-union. Importantly, all non-union cases involved open fractures, leading the authors to suggest that open distal tibial fractures in cats may be particularly predisposed to impaired healing (33). In the present case, internal stabilization was performed using a locking plate and an intramedullary pin, a technique providing greater mechanical stability than an external fixator alone. However, it should be emphasized that even a relatively stable plate–rod construct does not eliminate the risk of non-union when

the fracture is biologically unfavorable. In the present case, the primary injury was an open, comminuted, non-reconstructable fracture of the tibia and fibula, and the subsequent course of treatment was complicated by impaired soft tissue healing and infection. These factors may have substantially reduced the biological healing potential and contributed to persistent tibial non-union despite the use of internal fixation.

Successful reconstruction of large tibial defects and non-union in cats has been described, although such outcomes typically require active surgical management. For example, Kim et al. achieved complete cortical bridging and a good long-term outcome in a cat with an infected tibial non-union treated with revision plate stabilization combined with autologous bone graft, rhBMP-2, and a composite xenograft (16), illustrating that definitive reconstruction generally requires addressing both mechanical stability and the biological environment for healing. In the present case, complete tibial union was not achieved, and advanced reconstruction was not pursued because the owner could not meet the associated costs. This must not be regarded as the standard of care, nor as an acceptable alternative to definitive reconstruction simply because some limb function happened to be preserved; it reflects a constrained but informed decision made jointly with the owner, under continued veterinary oversight. In the absence of financial limitations, revision stabilization with bone grafting would normally have been recommended and remained the treatment of choice offered throughout. The progressive fibular hypertrophy observed in this cat should be interpreted as a compensatory adaptive change, not as a substitute for tibial reconstruction, and its favorable course does not diminish the general recommendation that definitive reconstruction be pursued whenever feasible. Had conservative management failed at any point, revision surgery or limb amputation would have been pursued without delay.

It should be emphasized, however, that the patient requires continued regular orthopedic and radiographic follow-up. Radiographs obtained three years after the initial surgery showed features of progressive remodeling within the tibia, and the gap between the bone fragments appeared smaller (Fig. 5) compared with earlier follow-up examinations (Figs. 2 and 3). This may suggest slow, late reparative activity; however, because of the persistent incomplete union and the unusual limb biomechanics, the patient should remain under regular veterinary supervision. At the three-year follow-up, further reconstructive options-including restabilization, bone grafting, or fibular transposition/grafting-were again reviewed with the owner, who continued to opt for ongoing clinical and radiographic monitoring rather than further surgery, a choice supported by the cat's stable clinical status over the preceding years.

The most remarkable finding of this case was the pronounced hypertrophy and remodeling of the fibula despite persistent tibial non-union. During the three-year follow-up period, the fibular diameter increased progressively, while the cat continued to use the affected limb. Quantitative analysis demonstrated that fibular enlargement was most pronounced during the first 7.5 months of follow-up, after which the rate of increase slowed, although progressive remodeling remained evident throughout the 32.8-month observation period (Tab. 1, Fig. 4). The total fibular diameter increased by 260.0% in the craniocaudal projection and by 318.8% in the mediolateral projection relative to baseline. These findings suggest that the fibula may have been subjected to increased mechanical loading as a consequence of altered force distribution caused by the persistent tibial defect. This interpretation is consistent with Wolff's law, according to which the bone adapts its internal architecture and external morphology in response to mechanical loading (8). Increased repetitive loading may stimulate bone formation and cortical thickening, whereas reduced loading promotes bone resorption (2). Therefore, chronic redistribution of mechanical forces from the non-united tibia toward the fibula represents a plausible explanation for the progressive fibular hypertrophy observed in this patient. However, this mechanism remains hypothetical, because no force-plate analysis, kinetic or kinematic gait assessment, or CT-based biomechanical evaluation was performed to quantify load transmission through the fibula. The radiographic and clinical findings should therefore be interpreted as compatible with increased mechanical loading rather than as definitive evidence that the fibula assumed a substantial weight-bearing function.

Comparable findings have been reported in humans. Prabhat et al. described two patients with long-standing tibial non-union (10 and 20 years) in whom the fibula progressively hypertrophied and assumed a weight-bearing role, a phenomenon the authors termed "natural tibialization of the fibula", attributing it to long-term mechanical overload consistent with Wolff's law (26). Unlike that report, in which remodeling was identified incidentally many years after injury, the present case was followed prospectively for three years, allowing the successive stages of adaptive change to be documented directly. As in the human cases, progressive fibular hypertrophy in this cat should be regarded as a compensatory mechanism that may help preserve some limb use, rather than as a substitute for restoring normal tibial function.

Fibular hypertrophy with a similar mechanistic basis has also been described after planned surgical procedures that place the fibula in a weight-bearing role. Falder et al. reported gradual hypertrophy of free vascularized fibular grafts in most of 32 patients, with the degree of hypertrophy directly related to the mechani-

cal load the graft carried, and minimal hypertrophy when the graft was stress-shielded (6). Although these grafts were surgically transplanted rather than adapting spontaneously, the findings support mechanical loading as the key stimulus for fibular hypertrophy, consistent with the process proposed in the present case.

Qi et al. described three patients with vascularized fibular grafts for large tibial defects, in whom hypertrophy was most pronounced after a stress fracture triggered additional bone remodeling, while grafts without a stress fracture showed little hypertrophy (27). No radiographic evidence of fibular stress fracture was observed in the present cat, suggesting that gradual chronic overload, rather than a single mechanical failure event, was the primary stimulus for its adaptive remodeling.

Kassab et al. reported a 12-year follow-up of ipsilateral fibular transposition (the Huntington procedure) in 11 patients with tibial non-union, in which the transposed fibula acted as a biological plate and restored limb function in most cases (15). Although this involved a planned surgical transposition rather than spontaneous adaptation, it further illustrates the capacity of the fibula to assume a weight-bearing role when the tibia cannot transmit load, as appears to have occurred in the present cat.

Persistent discontinuity of the tibia is expected to have altered the distribution of forces within the affected limb. Physiologically, the tibia is the main weight-bearing element of the pelvic limb, whereas the fibula plays a much smaller role in axial load transmission. In the setting of chronic tibial non-union, this biomechanical arrangement was disrupted, and part of the forces transmitted during weight bearing may have been gradually redirected to the fibula. Removal of the bone plate while retaining the intramedullary pin may also have influenced the mechanical environment. The retained pin may have helped maintain partial limb alignment but was unlikely to provide complete stability at the tibial non-union site. Experimental studies using tibial gap models have demonstrated that the mechanical behavior and stiffness of plate–rod constructs depend on the implant configuration and loading conditions (25). This configuration most likely allowed partial maintenance of limb alignment, but did not provide complete stability at the tibial non-union site. As a result, the fibula, as a continuous osseous structure connecting the proximal and distal segments of the pelvic limb, may have been subjected to increased repetitive mechanical loading over a prolonged period. The gradual increase in these forces may have stimulated bone remodeling, cortical thickening, and an increase in bone diameter. This mechanism provides a likely explanation for the adaptive fibular hypertrophy observed on consecutive radiographic examinations and its apparent assumption of a weight-bearing role in the limb.

Based on our literature search, no comparable long-term veterinary report of progressive fibular hypertrophy secondary to feline tibial non-union was identified. Other veterinary studies, however, support Wolff's law-consistent remodeling in response to chronic directional loading: Johnson et al. demonstrated greater mineral density and trabecular thickening in the central tarsal bone of the outside limb of racing Greyhounds, an asymmetry that diminished after retirement from racing (14). Although this concerned an athletic dog's tarsal bone rather than a cat's tibia and fibula, the underlying mechanism-chronic asymmetric loading driving localized bone remodeling-parallels the process proposed for the present case.

Further evidence of the adaptive capacity of animal bone comes from dogs after TPLO, in which proximal tibial geometry continues to change months after clinical healing (20), and from horses, in which training-related loading alters bone mineral content and morphology (7). These examples, however, mainly reflect adaptation to controlled, physiological loading in athletic animals or after planned procedures, whereas the present case involved chronic tibial non-union and markedly altered limb biomechanics. This case may therefore serve as a useful reference point, and the authors encourage veterinarians to document and publish similar cases to better characterize compensatory bone remodeling in small animals and its significance for long-term limb function.

This case should not be interpreted as an argument in favor of conservative management of tibial non-union in cats, because standard treatment in such situations should aim to restore mechanical stability and improve the biological conditions for bone healing. The conservative approach followed here was adopted solely because of the owner's financial constraints and must not be regarded as a recommended treatment model for feline tibial non-union. Where clinically and financially feasible, revision surgery with bone grafting or other reconstructive techniques, or limb amputation when reconstruction is not possible, should generally be considered. However, this case represents an unusual example of the feline skeletal system's capacity for long-term compensation under conditions of markedly altered limb biomechanics. Further clinical and radiographic follow-up is necessary to assess the stability of this adaptation, any possible late progression of tibial healing, and the cat's welfare, including pain, mobility, spontaneous limb use, activity level, and overall quality of life.

Conclusions. The present case suggests an unusual phenomenon of spontaneous adaptive tibialization of the fibula in a cat with persistent tibial non-union. Despite failure of tibial healing and the absence of advanced reconstructive treatment, three-year radiographic follow-up demonstrated progressive hyper-

trophy and remodeling of the fibula, while the cat continued to use the affected limb. These findings are compatible with chronic redistribution of mechanical loading from the non-united tibia to the fibula and adaptive bone remodeling consistent with Wolff's law. However, this interpretation remains hypothetical because no objective biomechanical assessment, such as force-plate analysis or instrumented gait evaluation, was performed, and limb function was not assessed using a standardized clinical scoring system.

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