

# Treatment of diabetic foot during the COVID-19 pandemic

## A systematic review

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### Abstract

**Background:** In the context of the novel coronavirus disease 2019 (COVID-19) pandemic, people have had to stay at home more and make fewer trips to the hospital. Furthermore, hospitals give priority to the treatment of COVID-19 patients. These factors are not conducive to the treatment of diabetic foot, and even increase the risk of amputation. Therefore, how to better treat patients with diabetic foot during the COVID-19 epidemic, prevent further aggravation of the disease and reduce the risk of amputation in patients with diabetic foot has become an urgent problem for doctors around the world.

**Methods:** The researchers searched PubMed, the Cochrane Library, and the Embase database. The retrieval time was set from the database establishment to October 2021. All studies on treatment of diabetic foot in the COVID-19 pandemic were included in our study.

**Results:** A total of 6 studies were included in this study. In the 6 protocols for treating patients with diabetic foot, the researchers classified patients according to the condition of their diabetic foot. Diabetic foot patients with general conditions received treatment at home, and doctors can guide the wound dressing change and medication treatment of patients through telemedicine. Patients with severe conditions of diabetic foot were admitted to hospital for treatment. Patients were screened for COVID-19 before hospitalization, those infected or suspected of COVID-19 were treated in isolation, and those not infected with COVID-19 were treated in a general ward.

**Conclusion:** Through this systematic review, we proposed a new protocol for the treatment of patients with diabetic foot in the context of the COVID-19 pandemic. It provided reference for the treatment of diabetic foot in the context of COVID-19 epidemic. However, the global applicability of the treatment protocol for diabetic foot in the context of COVID-19 epidemic proposed in this study needs further clinical testing.

**Abbreviation:** COVID-19 = novel coronavirus disease 2019.

**Keywords:** COVID-19, diabetes mellitus, diabetic foot, diabetic foot ulcer, SARS-CoV-2

## 1. Introduction

The novel coronavirus disease 2019 (COVID-19) epidemic, which began in 2019, is not over yet.<sup>[1]</sup> So far, >85 million people worldwide have been infected with COVID-19 and >1.8 million have died from COVID-19.<sup>[2]</sup> In the context of the COVID-19 global pandemic, the treatment of diabetic foot may be wrongly classified as unnecessary. But without regular diabetic foot care or surgical intervention, patients with diabetic foot risk rapid wound infection, which can lead to amputation and death.<sup>[3]</sup> Study has showed that people with diabetes are more susceptible to COVID-19 and have a higher risk of death.<sup>[4]</sup>

Diabetic foot ulcer is a more common complication in diabetic patients, and up to one-third of diabetic patients will develop diabetic foot ulcer symptoms.<sup>[5]</sup> Severe diabetic foot ulcers can lead to amputation, disability and even death. The conventional treatment of diabetic foot is mainly to control blood glucose under the supervision of doctors and change dressing on ulcer wounds. Patients with severe diabetic foot ulcer need to be hospitalized.<sup>[6]</sup> However, the COVID-19 epidemic has changed the treatment model of diabetic foot, bringing great challenges to the treatment of diabetic foot.

In the context of the COVID-19 pandemic, people have had to stay at home more and make fewer trips to the hospital. Furthermore, hospitals give priority to the treatment of

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This article does not contain any studies with human participants or animals performed by any of the authors. The medical ethics committee approval is not required for this type of study.

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COVID-19 patients.<sup>[7]</sup> These factors are not conducive to the treatment of diabetic foot, and even increase the risk of amputation. Therefore, how to better treat patients with diabetic foot during the COVID-19 epidemic, prevent further aggravation of the disease and reduce the risk of amputation in patients with diabetic foot has become an urgent problem for doctors around the world. In order to solve this problem, we searched relevant literature and systematically reviewed the measures taken by doctors in various countries to treat diabetic foot in the context of COVID-19 pandemic, hoping to find effective methods to treat diabetic foot in the context of COVID-19 epidemic and provide reference for clinicians in the treatment of diabetic foot.

## 2. Methods

### 2.1. Search strategy

The researchers searched PubMed, the Cochrane Library, and the Embase database. The retrieval time was set from the database establishment to October 2021. Keywords retrieved were “Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2),” “COVID-19,” “Diabetes Mellitus,” “Diabetic Foot,” and “Diabetic Foot Ulcer.” This search has no language restrictions or research type restrictions.

### 2.2. Inclusion and exclusion criteria

**2.2.1. Inclusion criteria.** Studies on the treatment of diabetic foot in the COVID-19 pandemic. The subjects were patients with diabetic foot, not animals or cells. Specific measures to treat diabetic foot in the context of the COVID-19 pandemic are described in the studies.

**2.2.2. Exclusion criteria.** Duplicate publications. No specific measures to treat diabetic foot in the context of the COVID-19 pandemic are described in the studies. The subjects were animals or cells.

### 2.3. Data extraction and data synthesis

Information was extracted from the included articles by 2 researchers, including the first authors’ name, time of publication, authors’ countries, and the specific measures to treat diabetic foot in the context of the COVID-19 pandemic. The findings of articles included in our study will be pooled and presented in the results section in the form of narration and tables.

## 3. Results

By searching the database, a total of 65 related articles were retrieved. Two researchers screened the study by reading abstracts and full texts, and a total of 6 literatures were included.<sup>[8–13]</sup> The selection process was shown in Figure 1. The characteristics of the 6 included articles are shown in Table 1.

In Osman Kelahmetoglu protocol,<sup>[8]</sup> doctors first graded the patients’ wound levels and the degree of infection. Different treatment measures were taken according to patients’ different conditions. Once a patient had a fever, regardless of the degree of wound infection, COVID-19 screening should be prioritized, and isolation treatment should be conducted if confirmed. Diabetic foot wounds without infection or mild infection can be treated at home, and telemedicine follow-up was conducted once a week. Patients with moderate infection of diabetic foot

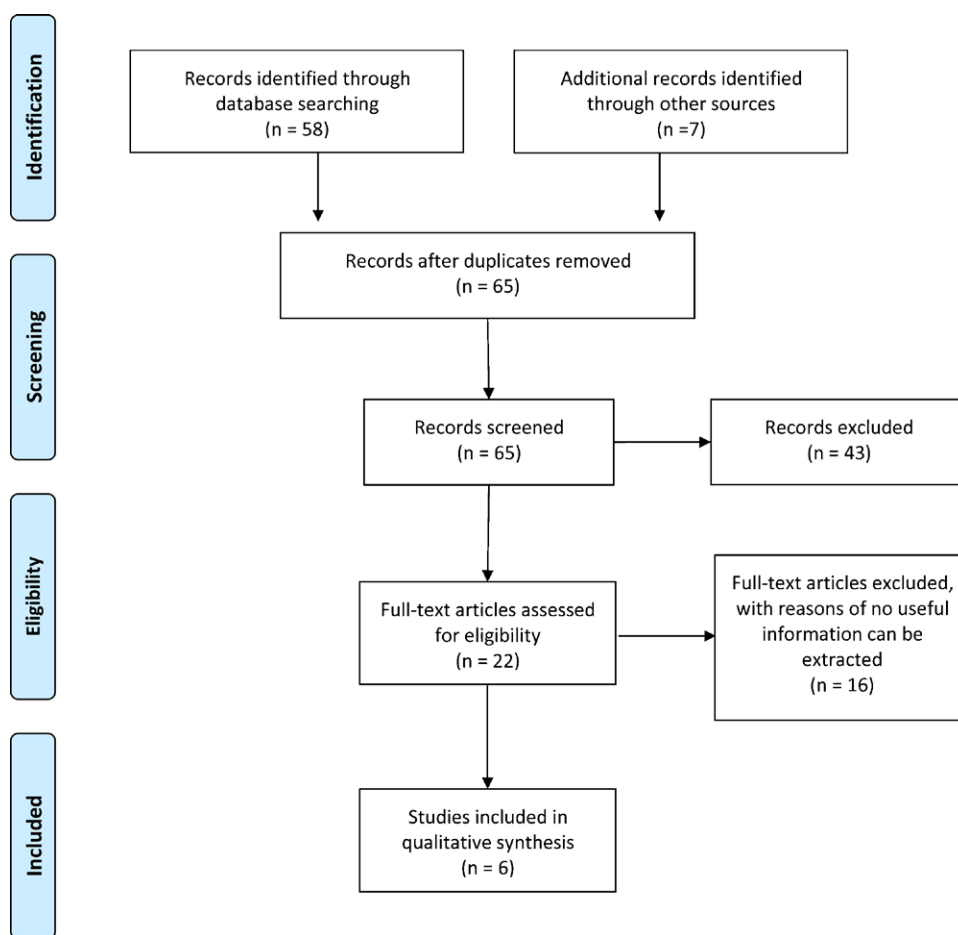


Figure 1. PRISMA flow diagram. PRISMA = preferred reporting items for systematic reviews and meta-analyses.

**Table 1****Summary table of included studies.**

Study	Year	Country	Specific measures
Kelahmetoglu et al <sup>[8]</sup>	2020	Turkey	<p>1. Evaluation of the wound and degree of infection</p> <p>If there is no infection or mild infection in the wound, and there is no fever, local wound care is sufficient at home and weekly online consultation can be planned.</p> <p>If there is no infection or mild infection in the wound, and a fever is present, local wound care and COVID-19 investigation should be recommended with nasopharyngeal swab</p> <p>If there is moderate infection in the wound, and there is no fever, debridement at outpatient clinic and local wound care are sufficient at home and weekly online consultation can be planned</p> <p>If there is moderate infection in the wound, and a fever is present, debridement at outpatient clinic and then local wound care are advised and COVID-19 investigation should be recommended with nasopharyngeal swab.</p> <p>If there are severe infection signs, hospitalization is needed. Treatment for DFU infection (such as intravenous antibiotics, fluid replacement, correction of electrolytes imbalance, glucose control, etc) with investigation of COVID-19. Even amputation.</p> <p>2. Online consultation to decrease the number of hospital visits</p> <p>The authors strongly recommend the use of thorax computerized tomography for preoperative screening in all DFU patients with severe signs of infection and especially those requiring urgent surgery for both the detection of the possible undiagnosed COVID-19 in the patient for the need for close follow-up and protection of the surgical and anesthesiology team</p>
Meloni et al <sup>[9]</sup>	2020	Italy	<p>1. Severely complicated ulcers: urgent hospitalization</p> <p>2. Complicated ulcers (<math>\geq 3</math> comorbidities): first visit and follow-up by telemedicine. In the case of ulcer impairment clinical reevaluation should be performed.</p> <p>3. Complicated ulcers (<math>\leq 2</math> comorbidities): first visit and regular follow-up, according to individual circumstance</p> <p>4. Uncomplicated ulcers: first visit and follow-up by telemedicine</p> <p>5. Healed ulcers: follow-up by telemedicine</p>
Jaly et al <sup>[10]</sup>	2020	United Kingdom	<p>1. Patient education and the use of online resources. Reminder to maintain glycemic control through diet, exercise and correct medication. Develop patient understanding of diabetic foot and risks of complications.</p> <p>2. Encouragement of self-examination of feet and regular foot care. Prevent the creation of pressure points around the foot and development of callosities. Potential to detect and report signs of ulceration or infection early.</p> <p>3. Telemedicine Consultations. Allows triaging of patients and assessment of new referrals. Visualization and evaluation of new or recently healed ulcers and assessment of the 'at risk' foot.</p>
Tao et al <sup>[11]</sup>	2020	China	<p>1. Screening and preliminary management of COVID-19 in patients with DFUs.</p> <p>2. Management of patients without COVID-19 who have DFUs: conservative treatment, interventional treatment, debridement, local decompression and amputation were adopted according to the severity of diabetic foot.</p> <p>3. Management of patients with DFUs and suspected or confirmed COVID-19: first, the patients were quarantined. Asymptomatic infected persons or those with mild symptoms of COVID-19 can be treated for diabetic foot in isolation conditions. If COVID-19 symptoms are severe, COVID-19 treatment should be prioritized to ensure the safety of patients. If a patient has suspected or confirmed COVID-19 and requires surgery, the operation must proceed under strict protective conditions.</p>
Atri et al <sup>[12]</sup>	2020	India	<p>It is essential that these patients continue receiving appropriate care while minimizing their need to visit the hospital, and the aim of the physician should be to shift focus away from hospital-based care. Most patients with diabetic foot disease do not require hospitalization, unless they have severe infection with possible sepsis or require surgical intervention. By triaging patients, most can be managed as outpatients with homecare, telemedicine appointments where possible and by setting up clinics at other locations outside of the hospital, with assistance as required from multidisciplinary diabetic foot clinics.</p>
Rogers et al <sup>[13]</sup>	2020	America	<p>1. The authors strongly recommend implementing a triage system for lower-extremity wounds and diabetic foot problems, which will drive the site and urgency of podiatric care.</p> <p>2. Shift away from hospital-based care</p> <p>3. Increased use of telemedicine and remote patient monitoring</p> <p>4. More in-home visits: podiatrists can order home health visits, dressing changes, and/or prescribe dressings and antibiotics to be used at home by the patient.</p>

COVID-19 = novel coronavirus disease 2019; DFU = diabetic foot ulcer.

wounds can be treated in the outpatient clinic, and telemedicine follow-up was conducted once a week. Patients with diabetic foot wounds with serious signs of infection need to be hospitalized. Treatment for diabetic foot ulcer infection was intravenous antibiotics, fluid replacement, correction of electrolytes imbalance, glucose control, etc. Moreover, the authors recommended online counseling for patients to reduce the number of hospital visits and the use of thorax computerized tomography for preoperative screening in all diabetic foot ulcer patients with severe signs of infection.

In Marco Meloni protocol,<sup>[9]</sup> the doctor first assessed the patients' condition. The fast-track-pathway classification method was used to grade diabetic foot. Critical diabetic foot patients with severe complications (wet gangrene, abscess, fever, signs of sepsis, and acute critical limb ischemia) require

emergency hospitalization. Patients with diabetic foot with complex ulcers need to be evaluated on an outpatient basis, patients with severe ulcers need to be hospitalized for treatment, and patients without hospitalization can be followed up by telemedicine. Diabetic foot patients with complex ulcers with 3 or more complications were reevaluated on an outpatient basis only if the ulcers were aggravated. Diabetic foot patients with complex ulcers with 2 or less complications should be reevaluated according to individual circumstance. Telemedicine follow-up was performed for diabetic foot patients with less severe ulcer infection.

In Ibrahim Jaly protocol,<sup>[10]</sup> doctors used online resources to educate patients. They reminded glycemic control through diet, exercise and correct medication. They developed patient understanding of diabetic foot and risks of complications.

Diabetic foot patients were classified and condition evaluated and referred by telemedicine consultation.

In Fenghua Tao protocol,<sup>[11]</sup> patients with diabetic foot were first screened for COVID-19. Diabetic foot patients who are not infected with COVID-19 follow normal treatment procedures, conservative treatment, interventional treatment, debridement, local decompression and amputation were adopted according to the severity of diabetic foot. Patients with diabetic feet who are suspected or confirmed to have COVID-19 should be quarantined first. Patients with asymptomatic COVID-19 or mild symptoms of COVID-19 can be treated for diabetic foot in isolation conditions. If the symptoms of COVID-19 are severe, COVID-19 treatment should be prioritized to ensure the safety of patients. If a patient has suspected or confirmed COVID-19 and requires surgery, the operation must proceed under strict protective conditions.

In Avica Atri protocol,<sup>[12]</sup> medical staff need to give adequate care to patients with diabetic foot to minimize the number of visits to the hospital. Most patients with diabetic foot receive treatment and care at home. Patients with diabetic foot with severe infection may develop sepsis or require surgical intervention and need to go to hospital for treatment. Home care, telemedicine, and the establishment of clinics in other locations outside the hospital can fully meet the needs of patients with diabetic foot.

In Lee C. Rogers protocol,<sup>[13]</sup> a system of triage was established to keep patients classified into 4 grades: stable, guarded, serious and critical. Patients with the first 2 grades could receive telemedicine care at home, while those with the latter 2 grades would receive outpatient treatment or even hospitalization. The model of inpatient care needs to be changed, and doctors need to treat patients more on an outpatient basis and care for patients in their homes. Physicians need to use telemedicine to guide patients, such as Medicare Telehealth Visit, Virtual check-in, e-Visit, and Remote Patient Monitoring. Doctors can schedule more home health visits, and doctors can change wound dressings and administer antibiotics in patients' homes. The authors' goal was to ensure patients safety and reduce the burden on healthcare systems during the COVID-19 pandemic.

#### 4. Discussion

Foot ulcers are the most common complication of diabetes, with higher morbidity and mortality than many cancers. Refractory diabetic foot ulcers are a leading cause of hospitalization, amputation, disability and death in patients with diabetes.<sup>[14]</sup> The global pandemic of COVID-19 poses significant challenges to the management of people with diabetes, especially those with severe foot ulcers.<sup>[15]</sup> The conventional treatment schedules of diabetic foot is no longer suitable for the treatment of diabetic foot in the context of COVID-19 epidemic.<sup>[16]</sup> So we conducted this study by systematically reviewing relevant studies to find new treatment schedules of diabetic foot to better treat diabetic foot in the context of COVID-19 prevalence.

After a systematic review of the 6 articles included in this study, we concluded a new protocol for treating patients with diabetic foot in the context of the global COVID-19 pandemic. The severity of diabetic foot ulcer was assessed and classified into general (no wound or small wound, no infection, and stable condition), severe (complex and refractory infection wound), and critical (wet gangrene, abscess, fever, signs of sepsis, and acute critical limb ischemia). Diabetic foot patients with general conditions can receive treatment at home, and doctors can guide the wound dressing change and medication treatment of patients through telemedicine. Patients with severe conditions of diabetic foot need to go to the hospital outpatient clinic for debridement treatment after COVID-19 screening. Patients with severe diabetic foot diagnosed or suspected COVID-19 infection need debridement treatment in

isolation and continue to quarantine after treatment. Severe diabetic foot patients who were not infected with COVID-19 were sent home after debridement treatment in an outpatient clinic, where they were monitored by telemedicine and instructed by doctors on the next steps. Critical diabetic foot patients were hospitalized after being screened for COVID-19. Critical diabetic foot patients diagnosed or suspected COVID-19 infection need to be hospitalized in isolation. Patients with critical diabetic feet who were not infected with COVID-19 are hospitalized in general wards. The critical diabetic foot patients were treated with conservative treatment, interventional treatment, debridement, local decompression, amputation and other treatment measures according to their condition during hospitalization. In the context of the COVID-19 epidemic, the primary step in the treatment of diabetic foot ulcers is to assess the severity of diabetic foot ulcers. Diabetic foot ulcers can be caused by a variety of causes, including peripheral artery disease, infection, neuropathy, etc. Most classification systems focus only on the local pathology of diabetic foot ulcer (DFU) and fail to adequately assess all important parameters associated with ulcer healing. Whether telemedicine or face-to-face treatment, doctors should use the same evaluation system for diabetic foot ulcers. According to current and previous study, we recommended the Perfusion, Extent, Depth, Infection and Sensation (PEDIS) classification system. The PEDIS classification system was developed by the International Working Group of the Diabetic Foot (IWGDF), which all DFUs are classified according to 5 categories: perfusion, extent/size, depth/tissue loss, infection and sensation. Study<sup>[17]</sup> found that the PEDIS classification system has a sensitivity of 93% and a specificity of 82%. Therefore, the PEDIS classification system is more objective and exact to assess DFU to predict the clinical outcome.

A total of 6 relevant articles were included in this systematic review, from India, China, the United Kingdom, the United States, Italy, and Turkey, respectively. The types of articles will include introduction and letter, and there was no relevant data for meta-analysis. Based on the authors' protocols for treating diabetic foot in the context of the COVID-19 epidemic in 6 relevant articles, we obtained a more widely applicable protocol for treating diabetic foot. It provides reference for the treatment of diabetic foot in the context of COVID-19 epidemic. However, since the experience of doctors in Oceania and South America in treating diabetic foot in the context of COVID-19 epidemic was not used for reference, the global applicability of the treatment protocol for diabetic foot in the context of COVID-19 epidemic proposed in this study needs further clinical testing.

#### 5. Conclusion

Through this systematic review, we proposed a new protocol for the treatment of patients with diabetic foot in the context of the COVID-19 pandemic. It provided reference for the treatment of diabetic foot in the context of COVID-19 epidemic. However, the global applicability of the treatment protocol for diabetic foot in the context of COVID-19 epidemic proposed in this study needs further clinical testing.

#### Author contributions

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**Writing – review & editing:** Jingui Yan, Yiqing Xiao, Rui Cao, Yanjin Wang.

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