Masterthesis

Does dermoscopy rise the diagnostic accuracy in teledermatology

written by

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Abstract

Introduction/Background

Teledermatoloy has become very popular in the recent years, especially during the COVID-19 pandemic. Many studies investigate the advantages and disadvantages of that special medical service.

Objective

To investigate the contribution of dermoscopy to diagnostic accuracy in teledermatology.

Materials and methods

Fifteen general practitioners requested skin lesions within the framework of the research project “Teledermatology Styria”. Medical history was documented and clinical and dermatoscopic images were taken and transmitted as medical case via a store-and-forward teledermatology delivery service. Within 48 hours, two teledermatologists made a diagnosis and recommended a therapy. The author independently made a primary clinical diagnosis, a dermatoscopic diagnosis and a final diagnosis and assessed quality of dermatoscopic image and anamnesis of the medical case.

Results

A total of 491 skin lesions from 464 patients were telediagnosed from December 2019 to July 2020. Dermatoscopy changed primary clinical diagnosis of the author in 9.44% (29/307) of all medical cases. The diagnostic accuracy of the author increased from 72,02% to 88,69% with a dermatoscopic image for single skin lesions, that were primarily suspected for cutaneous neoplasms.

Conclusion

This master thesis shows that teledermatoscopy improves the diagnostic accuracy rate for single skin lesions, that are primarily suspicious for cutaneous neoplasms, fitting to the current literature. Additionally, the high number of undiagnosed medical requests

indicate the need of dermatological teleconsultations for general practitioners. We support the opinion that teledermatology can be used as a triage tool for skin cancer.

Abstract

Einleitung

Teledermatologie ist in den letzten Jahren sehr populär geworden, vor allem während der COVID-19 Pandemie. Viele Studien untersuchen die Vorteile und Nachteile dieses speziellen medizinischen Service.

Ziel

Um den Beitrag der Dermatoskopie für die diagnostische Treffsicherheit in der Teledermatologie zu untersuchen.

Material und Methoden

Im Rahmen des Forschungsprojekts „Teledermatologie Steiermark“ stellten 15 Hausärzte medizinische Anfragen bezüglich der Hautveränderungen ihrer Patienten. Die Anamnese, die klinischen und die dermatoskopischen Bilder wurden dokumentiert und als medizinsicher Fall teledermatologisch vorgestellt. Innerhalb von 48 Stunden stellten zwei Teledermatologen eine Diagnose und empfahlen eine Therapie. Der Autor stellte unabhängig davon, eine klinische Primärdiagnose, eine dermatoskopische Diagnose und eine Enddiagnose und bewertete die Qualität der dermatoskopischen Bilder und der Anamnesen.

Resultate

Insgesamt wurden von Dezember 2019 bis Juli 2020 491 Hautläsionen von 464 Patienten telediagnostiziert. Die Dermatoskopie veränderte die klinische Primärdiagnose des Autors in 9,44% (29/307) der Hautveränderungen. Die diagnostische Treffsicherheit des Autors erhöhte sich durch die Dermatoskopie von 72,02% auf 88,69% für einzelnstehende Hautläsionen, welche primär für eine Neoplasie verdächtig waren.

Schlussfolgerung

Diese Masterarbeit zeigt, dass die Teledermatoskopie die diagnostische Treffsicherheit von einzelnstehenden Hautläsionen, welche primär für eine kutane Neoplasie verdächtig sind, verbessert. Darüber hinaus weist die hohe Anzahl der nicht

diagnostizierten Hautveränderungen auf den Bedarf einer teledermatologischen Beratung für Allgemeinmediziner hin. Wir unterstützen die Meinung, dass die Teledermatologie zur Triage für Hautkrebs eingesetzt werden kann.

1. Introduction

1.1. Dermatoscopy

Dermatoscopy is a noninvasive, diagnostic technique. The user looks through a magnifying optical device, the so-called dermatoscope, to evaluate submacroscopic structures of the epidermis, the dermo-epidermal junction and the papillary dermis, which is impossible to the naked eye (1).

Based on the work of Paul Gerson Unna (1850-1929), who called his technique diascopy, the German dermatologist Johann Saphier was the first, who used immersion oil, while looking at the human skin through a binocular microscope and named the procedure dermatoscopy in 1920 (2). In that period of time the focus of interest was based on inflammatory diseases. Diagnosing pigmented skin lesions became popular in the last third of the 20th century (3).

Nowadays dermoscopy is the commonly used term, like some international organizations do it, while dermatoscopy seems to be the etymological correct form (2). Also known as the dermatologist's stethoscope, dermoscopy has spread from diagnosing melanocytic and nonmelanocytic skin lesions to the entire range of dermatology. It is used for inflammatory (inflammoscopy) and infectious diseases (entomodermoscopy), hair and scalp disorders (trichoscopy) and nail changes (onychoscopy) (1).

1.2. The classic handheld dermatoscope

In 1989 a handheld dermatoscope for the daily use was designed by Braun-Falco and co-workers (4). The classic handheld dermatoscope includes a specific, up to 10 times magnifying contact lens and a light source, which sends a beam of light to the skin (Figure 1) (1).

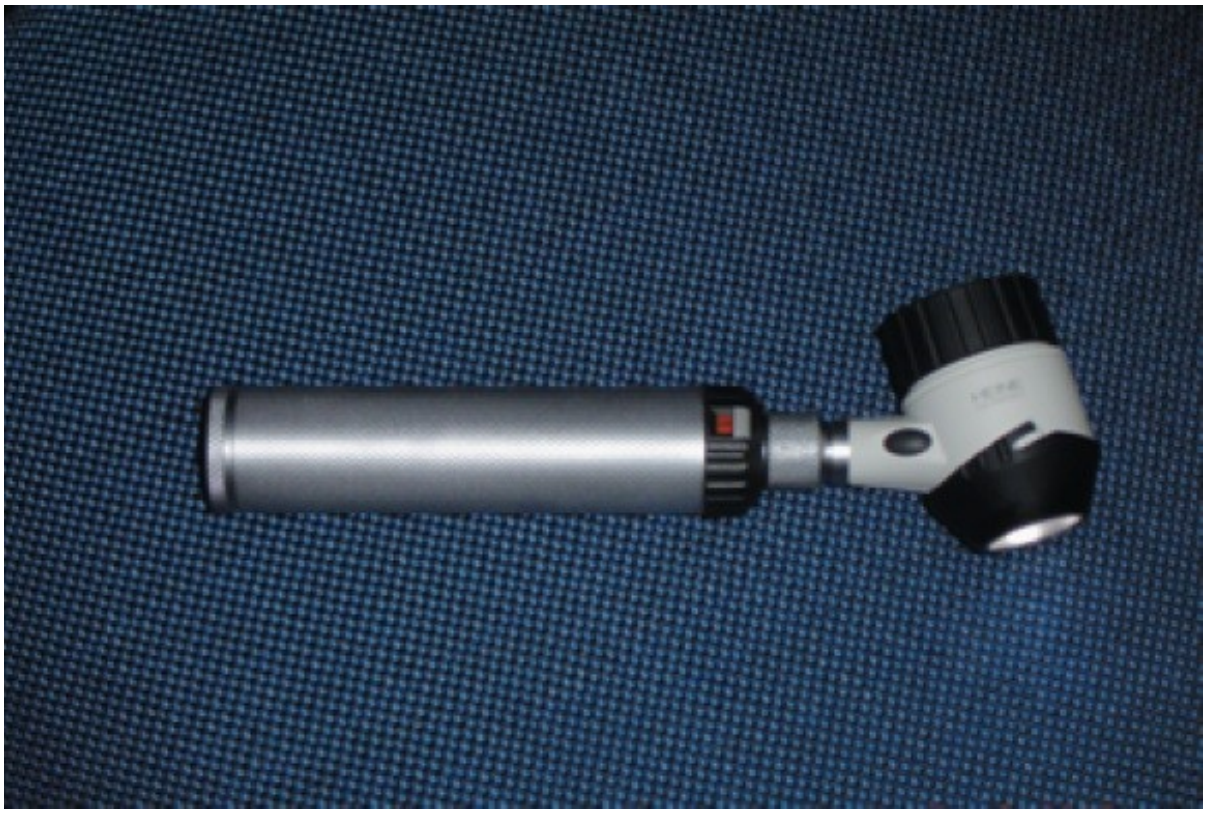

Figure 1. *Handheld dermatoscope*

Depending on the type light source, two dermoscopic methods exist, the non-polarized dermoscopy and the polarized dermoscopy (5). To eliminate light reflection and enable dermoscopic visualization in nonpolarized dermoscopy, it is required to use a special fluid medium, such as oil, alcohol or gel between the skin and the device's glass slide and put them in direct contact (1). The liquid interface reduces the air pockets and creates a smooth surface, rendering the stratum corneum more translucent and enabling the visualization of superficial structures. In that way relatively superficial structures like milia-like cysts and comedo-like openings of a seborrheic keratosis can be better evaluated with non-polarized dermoscopy (5).

Using a polarized light dermatoscope, it is not necessary to use an immersion liquid and apply direct skin contact. Two polarizing filters, which are placed perpendicular to each other in the dermatoscope, absorb the backscattered light from deeper areas of the skin and allow a better evaluation of deeper structures, such as fibrosis (1) (5).
In that way, knowing the advantages of each method (3), non-polarized dermoscopy and polarized dermoscopy; can complete one another (1).

1.3. The dermoscopy report

Since the use of dermoscopy has expanded to many fields of dermatology, the International Dermoscopy Society has created a dermoscopy report consensus document, which was published in 2007. This paper demonstrates a recommendation of a standardized dermoscopy report to facilitate documentation of dermoscopic findings and interdisciplinary communication. Ten points are listed and classified as “recommended” or “optional” in the document (Table 1) (6).

Main points	Criteria to be reported	Inclusion status*
1. Relevant clinical information about patient	Age, skin type, number of nevi, presence of large nevi, personal or family history of melanoma. In addition, history of change or symptoms of the lesion under investigation.	Recommended
2. Clinical description of lesion	Location, presence of clinical ABCDEs (*a*symmetry, *b*order irregularity, *c*olor variegation, *d*iameter >5 mm, and *e*volution)	Recommended
3. Two-step method	Relevant dermoscopic features to categorize lesion as melanocytic or nonmelanocytic	Recommended
4. Standardized terms	Use of standardized terms for describing dermoscopic structures and patterns (see Table III)	Recommended
5. Algorithm used	Algorithm to differentiate between benign and malignant melanocytic tumors (Tables IV-VII)	Optional
6. Imaging instrument	Type of equipment and magnification used	Recommended
7. Images of tumor	Clinical and/or dermoscopic images	Recommended
8. Diagnosis	Provide a specific diagnosis or a descriptive report and/or a differential diagnosis	Recommended
9. Suggested management	Final recommendations regarding management of lesion (eg, biopsy, excision, follow-up)	Recommended
10. Comments for pathologist	Information that may influence orientation and step-sectioning of specimen	Optional

*Definitions for inclusion status: “Recommended,” to be included in all reports; “Optional,” to be included in report if possible, albeit not necessary.

Table 1. *Dermoscopy report: Minimal criteria suggested by the IDS Board members (6)*

As a first step it is recommended to establish a medical history and investigate the patient for relevant clinical information at all and for the concerning skin lesion. After the patient’s history has been documented, a description of the clinical presentation of the skin lesion should be attached. It is recommended to differentiate a melanocytic from a nonmelanocytic lesion, followed by the selection of benign melanocytic lesions and melanomas, known as the two-step method. The fourth point recommends to use the standardized terms, while performing the two-step method (Table 2 and Table 3).

Dermoscopic criterion	Definition	Diagnostic significance
Pigment network—pseudonetwork*	Network of brownish interconnected lines overlying background of tan diffuse pigmentation. In facial skin a peculiar pigment network, also called pseudonetwork, is typified by round, equally sized network holes corresponding to preexisting follicular ostia	Melanocytic lesion
Aggregated globules	Numerous, variously sized, often clustered, round to oval structures with various shades of brown and gray-black. They should be differentiated from multiple blue-gray globules.	Melanocytic lesion
Streaks	These have been previously described separately as pseudopods and radial streaming, but are now combined into one term. They are bulbous and often kinked or finger-like projections seen at the edge of a lesion. They may arise from network structures but more commonly do not. They range in color from tan to black.	Melanocytic lesion
Homogeneous blue pigmentation†	Structureless blue pigmentation in absence of pigment network or other discernable structures	Melanocytic lesion
Parallel pattern	Seen in melanocytic lesions of palms/soles and mucosal areas. On palms/soles pigmentation may follow sulci or cristae (ie, furrows or ridges) of the dermatoglyphics. Rarely arranged at right angles to these structures.	Melanocytic lesion
Multiple milia-like cysts	Numerous, variously sized, white or yellowish, roundish structures	Seborrheic keratosis
Comedo-like openings	Brown-yellowish to brown-black, round to oval, sharply circumscribed keratotic plugs in the ostia of hair follicles. Irregularly shaped comedo-like openings are also called irregular crypts.	Seborrheic keratosis
Light brown fingerprint-like structures	Light brown, delicate, network-like structures with fingerprint pattern	Seborrheic keratosis
Cerebriform pattern	Dark brown furrows between ridges producing brain-like appearance	Seborrheic keratosis
Arborizing vessels	Tree-like branching telangiectases	Basal cell carcinoma‡
Leaf-like structures	Brown to gray/blue discrete bulbous structures forming leaf-like patterns. They are discrete pigmented nests (islands) never arising from pigment network and usually not arising from adjacent confluent pigmented areas.	Basal cell carcinoma‡
Large blue-gray ovoid nests	Well-circumscribed, confluent or near confluent pigmented ovoid or elongated areas, larger than globules, and not intimately connected to pigmented tumor body	Basal cell carcinoma‡
Multiple blue-gray globules	Multiple globules (not dots) that should be differentiated from multiple blue-gray dots (melanophages).	Basal cell carcinoma‡
Spoke-wheel areas	Well-circumscribed radial projections, usually tan but sometimes blue or gray, meeting at often darker (dark brown, black, or blue) central axis	Basal cell carcinoma‡
Ulceration§	Absence of epidermis often associated with congealed blood, not due to well-described recent history of trauma.	Basal cell carcinoma‡
Red-blue lacunae	More or less sharply demarcated, roundish or oval areas with reddish, red-bluish, or dark-red to black	Vascular lesion
Red-bluish to reddish-black homogeneous areas	Structureless homogeneous red-bluish to red-black areas	Vascular lesion
None of listed criteria	Absence of above-mentioned criteria	Melanocytic lesion

*Exception 1: Pigment network or pseudo-network is also present in solar lentigo and rarely in seborrheic keratosis and pigmented actinic keratosis. A delicate, annular pigment network is also commonly seen in dermatofibroma and accessory nipple (clue for diagnosis of dermatofibroma and accessory nipple: central white scar-like patch).

†Exception 2: Homogeneous blue pigmentation (dermoscopic hallmark of blue nevus) is also seen (uncommonly) in some hemangiomas and basal cell carcinomas and (commonly) in intradermal melanoma metastases.

‡To diagnose a basal cell carcinoma a pigment network must be absent and one or more of the positive features listed here such as spoke-wheel areas or leaf-like areas must be present.[35]

§Exception 3: Ulceration is also seen less commonly in invasive melanoma.

Table 2. *First step algorithm for differentiation between melanocytic and nonmelanocytic lesions according to the Consensus Net Meeting in Dermoscopy*

Dermoscopic criterion	Definition	Diagnostic significance
Global features		
Reticular pattern	Pigment network covering most parts of the lesion	Melanocytic nevus
Globular pattern	Numerous, variously sized, round to oval structures with various shades of brown and gray-black	Melanocytic nevus
Cobblestone pattern	Large, closely aggregated, somehow angulated globule-like structures resembling a cobblestone	Dermal nevus
Homogeneous pattern	Diffuse, brown, gray-blue to gray-black pigmentation in the absence of other distinctive local features	Melanocytic (blue) nevus
Starburst pattern	Pigmented streaks in a radial arrangement at edge of lesion	Spitz/Reed nevus
Parallel pattern	Pigmentation on palms/soles that follows sulci or cristae (furrows or ridges), occasionally arranged at right angles to these structures	Acral nevus/melanoma
Multicomponent pattern	Combination of ≥3 above-listed patterns	Melanoma
Nonspecific pattern	Pigmented lesion lacking above patterns	Possible melanoma
Local features		
Pigment network	Typical pigment network: light to dark brown network with small, uniformly spaced network holes and thin network lines distributed more or less regularly throughout lesion and usually thinning out at periphery.	Benign melanocytic lesion
	Atypical pigment network: black, brown, or gray network with irregular holes and thick lines	Melanoma
Dots/globules	Black, brown, round to oval, variously sized structures regularly or irregularly distributed within lesion	If regular, benign melanocytic lesion If irregular, melanoma
Streaks (pseudopods and radial streaming)	These have been previously described separately as pseudopods and radial streaming. Streaks are bulbous and often kinked or finger-like projections seen at the edge of a lesion. They may arise from network structures but more commonly do not. They range in color from tan to black.	If regular, benign melanocytic lesion (Spitz/Reed nevus) If irregular, melanoma
Blue-whitish veil	Irregular, structureless area of confluent blue pigmentation with an overlying white "ground-glass" film. Pigmentation cannot occupy entire lesion and usually corresponds to a clinically elevated part of the lesion	Melanoma
Regression structures	White scar-like depigmentation and/or blue pepper-like granules usually corresponding to a clinically flat part of the lesion	Melanoma
Hypopigmented areas (structureless/ homogeneous)	Focal areas devoid of structures with less pigmentation than overall pigmentation of lesion and comprising at least 10% of total area	Nonspecific
Blotches	Black, dark brown, and/or gray structureless areas with symmetric or asymmetric distribution within lesion	If symmetric, benign melanocytic lesion If asymmetric, melanoma
Vascular structures	Comma-like vessels	Dermal nevus
	Hairpin vessels	If uniformly distributed, seborrheic keratosis. If irregularly distributed, consider melanoma
	Dotted vessels	Melanoma
	Linear-irregular vessels	Melanoma
	Vessels and/or erythema within regression structures	Melanoma

Table 3. *Second-step algorithm. Pattern analysis criteria for the dermoscopic differentiation between benign melanocytic lesions and melanoma according to the Consensus Net Meeting on Dermoscopy*

In the consensus paper four algorithms were evaluated by the members of the International Dermoscopy society. In this context the pattern analysis, the ABCD rule of dermoscopy, the Menzie's method and the 7-point checklist can be used optionally to distinguish malignant and benign melanocytic lesions. The following recommended points of the document include a description of the imaging instrument, clinical and dermoscopic images of the tumor, the diagnosis and the suggested management. At least some information for the pathologist can be provided (6).

1.4. Teledermatology and Teledermoscopy

Telemedicine means offering medical services and information via telecommunication platforms to remote places. Transferring that working method into the field of dermatology, it's called teledermatology (7). The term was introduced to the English medical literature in 1995 for the first time and was related to the Oregon HPCC project, to provide that special medical service for dermatological conditions to underserved people in rural areas of the United States (8) (9). Teledermatology has evolved to one of the most used subspeciality of telemedicine in the last twenty years (10).

Basically, teledermatology can be provided in a synchronous, an asynchronous and a hybrid way. The synchronous or real-time (RT) teledermatology enables the patient and the teledermatologist acting in a live video conference. Questions concerning medical history can be asked and answered or instructions concerning treatment can be made immediately. But that kind of teledermatology delivery method is limited by the strength of the network, which might result in lower video quality and delays in live conference. By contrast the asynchronous or store-and-forward (SAF) teledermatology method divides into more working steps. At first the medical information including the patient's history and clinical images are digitally documented and saved by a clinician. In the second step the information is sent to a teleconsultant. At least the requested teledermatologist makes a diagnosis and therapeutic recommendation based on the provided information. That method is suitable to be practiced across time zones but limited to the impossibility of the teleconsultant to access further information at the time of consultation. The hybrid or mixed teledermatology combines the "real-time" and

“store-and-forward” modalities (7) (8). The general practitioner takes a picture of the patient’s skin condition, attached to a medical history and makes a requirement to the dermatologist. The teleconsultant answers the request with a phone call to the general practitioner to discuss the medical case including the diagnosis and the treatment. The advantages of the hybrid teledermatology are based on an already documented time-saving medical history and a high-quality picture of the skin disease for the teledermatologist (11).

Additional there are different settings of teledermatology, depending on the persons, who are involved in the working process. If a patient directly contacts a family doctor or dermatologist over a teledermatological service, it’s the primary setting. Secondary teledermatology takes place between the general practitioner and the teledermatologist, resulting in an indirect communication process between the patient and the specialist. Tertiary teledermatology means the exchange of information between specialists in the purpose of a “second” opinion. In that case, for example, a dermatologist gets a second opinion from a dermatopathologist. In patient assisted teledermatology a healthcare professional repeatedly has contact with a patient and controls the status of a chronic skin diseases, for example chronic ulcers. If the contact to the healthcare provider is created through a personal device of the patient, it’s called direct to costumer teledermatology (Figure 2).

A wide range of skin conditions already found their way into teledermatology. Skin cancer and benign neoplasm are the most treated indications investigated in teledermatology. Further skin conditions, which are examined are papulosquamous dermatoses, drug eruptions, inflammatory diseases, infections, hair and nail disorders, wounds, alopecia and acne (12). Most studies indicate, that diagnostic accuracy rate of teledermatology is similar to clinical dermatology (8). If a dermatoscopic picture is added to the entire working method, the consultation is called teledermatoscopy. By contrast to the variety of dermatological conditions treated in teledermatology, teledermatoscopy mostly investigates melanocytic and keratinocytic lesions as part of triage system for skin cancer (12). Literature data shows, that teledermoscopy improves diagnostic accuracy in the secondary and tertiary setting of teledermatology and ranges from 51%-94% when compared to histopathology for excised lesions and to in dermatologist visit for non-excised lesions (13).

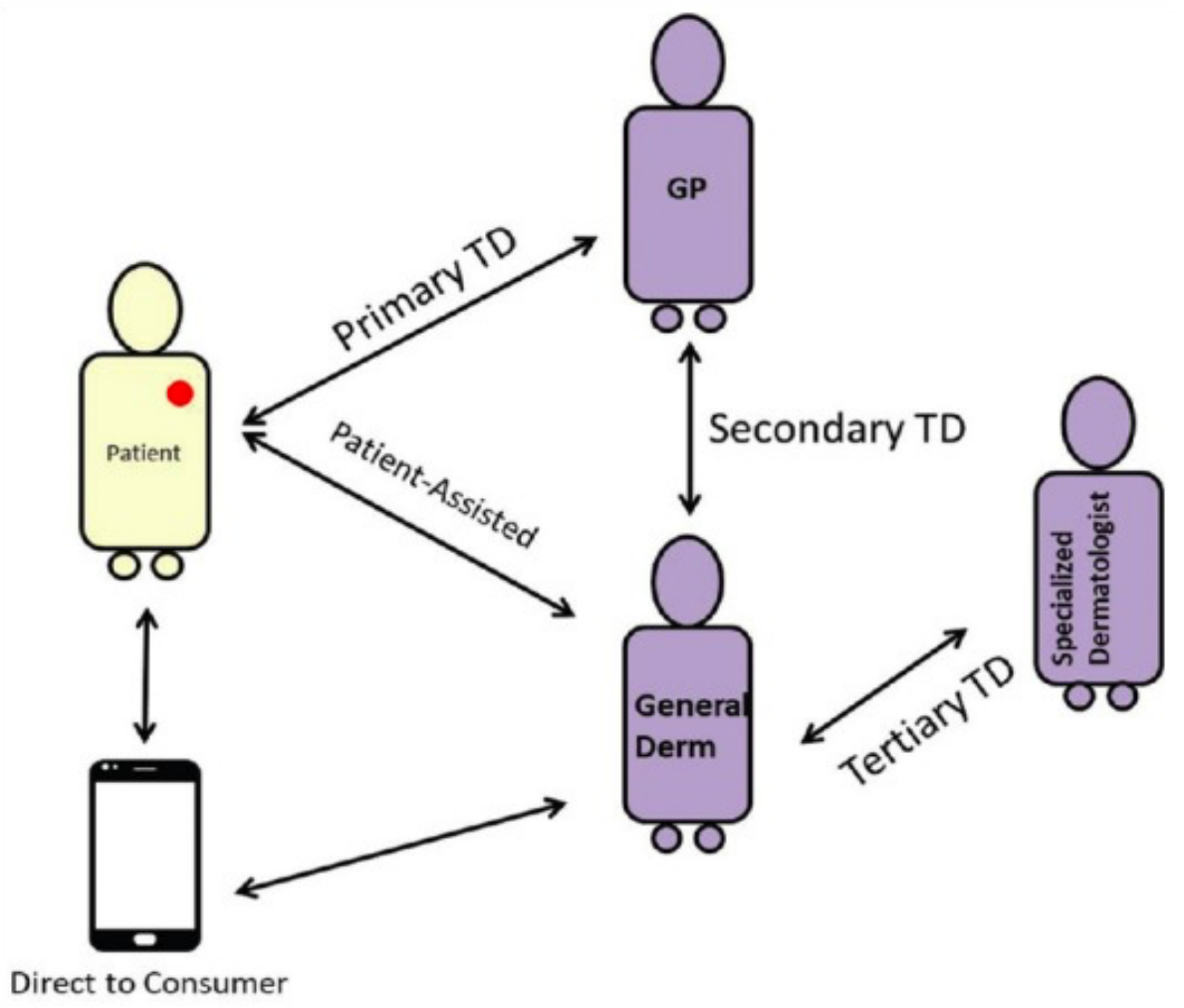

Figure 2. *Types of teledermatology*

2. Methods and material

2.1. Methodical processing

The master thesis relies on two methodical procedures. At first step the available data from the research project “Teledermatology Styria” have been collected and evaluated from the internet platform “liezen.telederm.at”. In connection the data were statistically analysed. At second step a comprehensive literature research was carried out, focusing on the added value of dermatoscopy in the diagnostic process of skin diseases and the use of dermatoscopy in teledermatology.

2.2. Data collection

As part of the secondary, store-and-forward teledermatology research project “Teledermatology Styria” fifteen general practitioners have made medical enquiries about patients, who have been treated in their ordinations, to two teledermatologists. The patients were enlightened and had to sign an informed consent. Then the requester has created a medical file on the internet platform “liezen.telederm.at” in that teleconsulting process. Following criteria had to be specified by the general practitioners: diagnosis (if they were able to), name, gender, age, location of the skin change, patient’s history and pre-therapy. The clinical and dermatoscopic pictures were taken with a 3GEN DL1 Epiluminescence Dermlite Dermatoscope, attached to an iPad mini (4th generation) (Figure 3). Clinical pictures were documented with a certain distance between the skin change and the camera. Dermatoscopic images were taken with contact dermatoscopy (Figure 4). The general practitioners were taught how to take dermatoscopic images, but they didn´t receive a training course in dermatoscopy. At least the general practitioners could add available documents for example laboratory tests or histological results. Two dermatologists reviewed the medical cases and had to make a primary diagnosis, differential diagnoses and a therapeutic proposal within 48 hours. The general practitioner and the

teledermatologist were able to communicate with each other through a chat function on the internet platform (Figure 5).

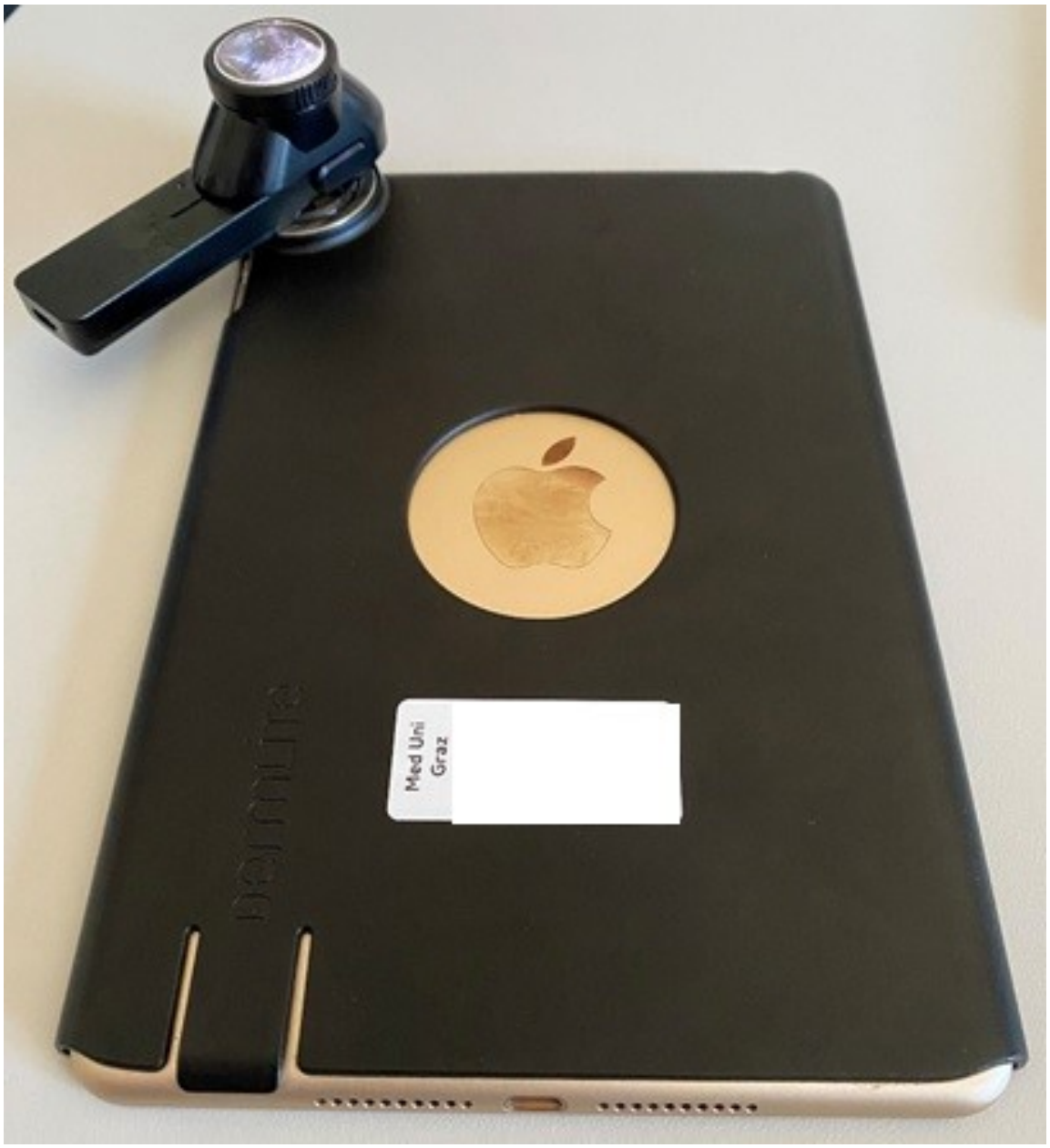

Figure 3. *3GEN DL1 Epiluminescence Dermlite Dermatoscope attached on an iPad mini (4th generation) for clinical and dermatoscopic photodocumentation.*

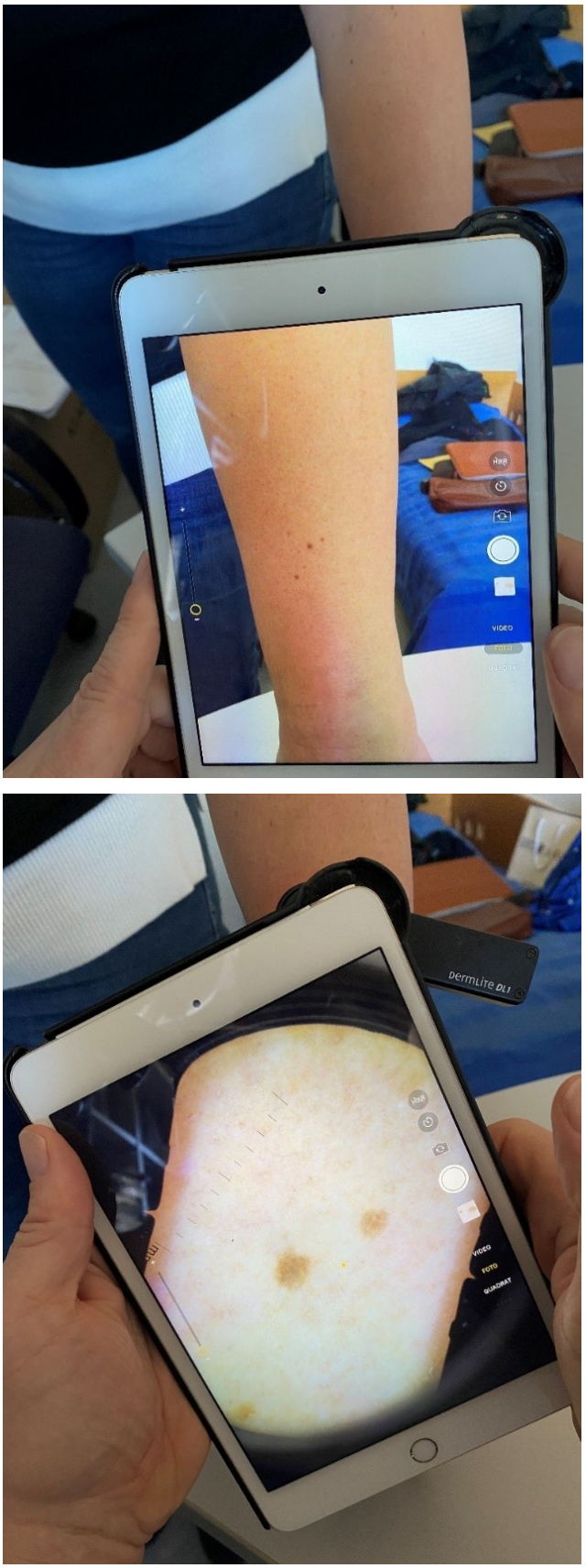

Figure 4. *Example for clinical and dermatoscopic photo documentation*

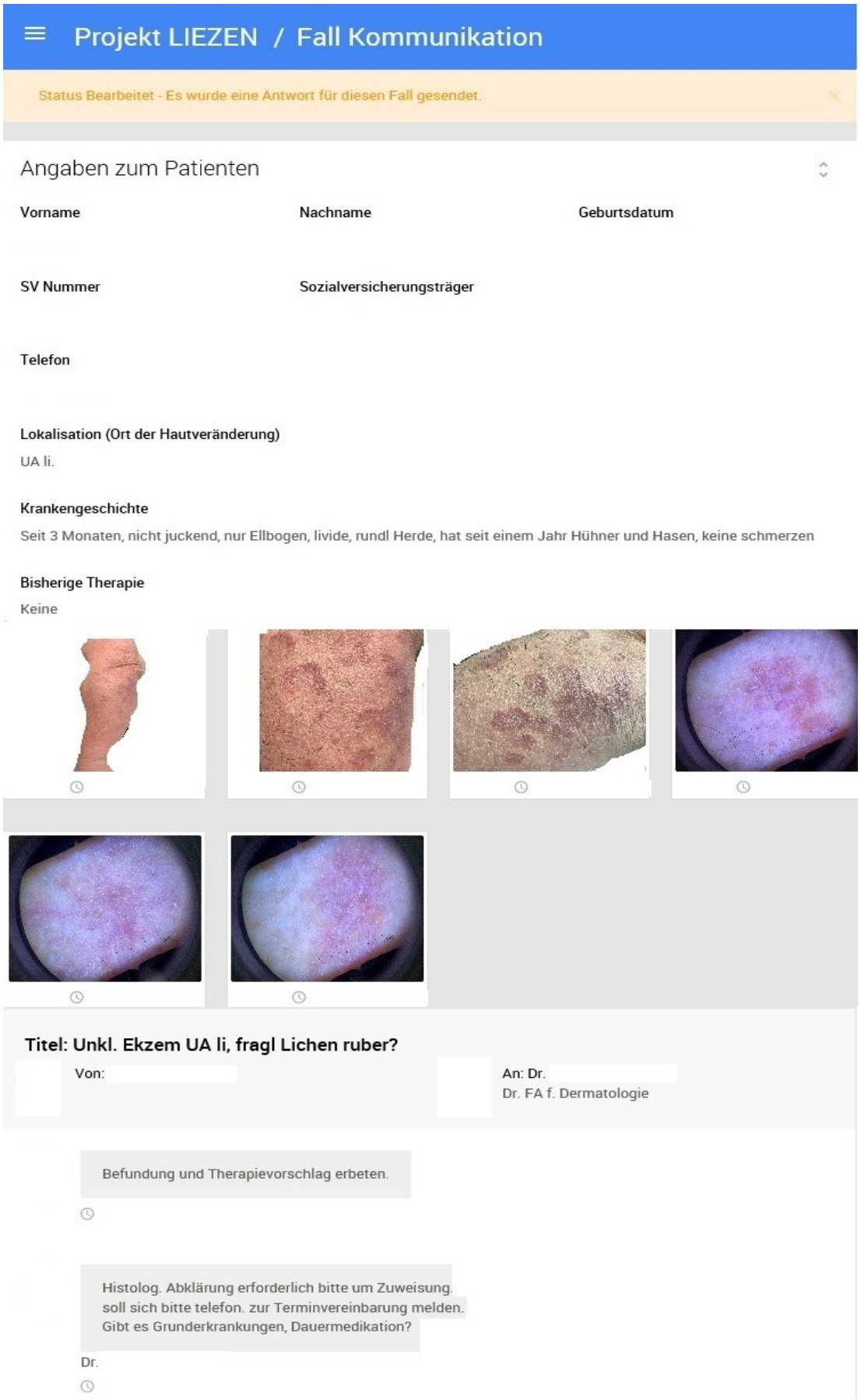

Figure 5. *Surface of the internet platform for teledermatology Styria – "liezen.derm"*

2.3. Study population

491 skin lesions were enrolled to that prospective study with a retrospective view from 464 patients, corresponding to 464 medical files, which were locked in the research project “Teledermatology Styria” from December 2019 to July 2020. In order to represent real-time conditions of teledermatology, all medical files were taken for evaluation during this period, regardless of the quality of the clinical or dermatoscopic pictures or the patient’s histories.

2.4. Evaluation of the data from the research project “Teledermatology Styria”

The evaluation of the available data consisted of several steps. At first the author of the present master thesis had to make a diagnosis and up to two differential diagnoses based on the clinical pictures of a medical file without any further information. In the second step the author had to make a further diagnosis with the information offered by the dermatoscopic picture, if available. In the last working process, he was allowed to read the medical history, which was recorded by a general practitioner and had to make a final diagnosis.

2.5. Statistical Analysis of the data from the research project “Teledermatology Styria”

The primary clinical diagnosis, the dermatoscopic diagnosis as well as the final diagnosis of the author and the diagnosis of the general practitioner have been compared to the diagnosis of the teledermatologists.

3. Results

3.1. General data

491 skin lesions from 464 medical cases corresponding to 464 patients (227 men, 237 women) were included into the study. 37,47% (184/491) of skin lesions were documented without a dermatoscopic image from the general practitioner. 62,52% (307/491) of skin lesions were also depicted with a dermatoscopic image (Figure 6). The general practitioners diagnosed 26,27% (129/491) of the skin lesions, but requested 73,72% (362/491) of the skin lesions without a diagnosis to the teleconsultant (Figure 7).

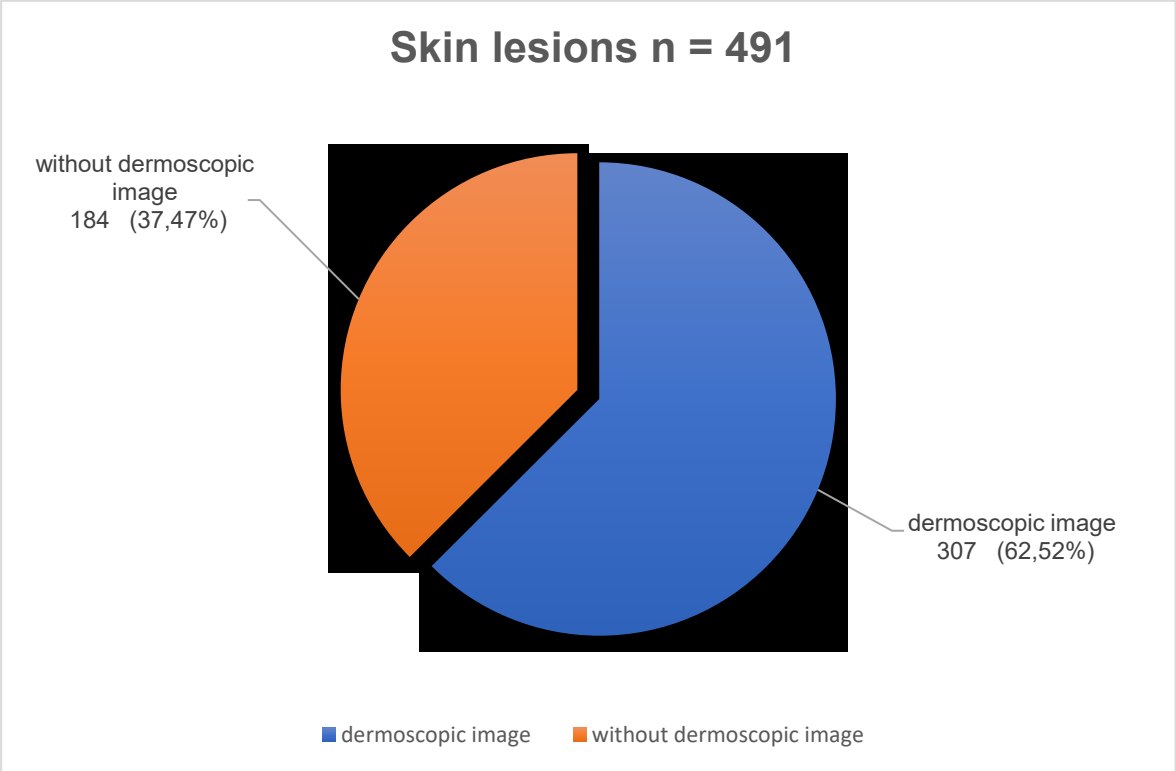

Figure 6. *General data - overview of skin lesions with/without dermatoscopic picture*

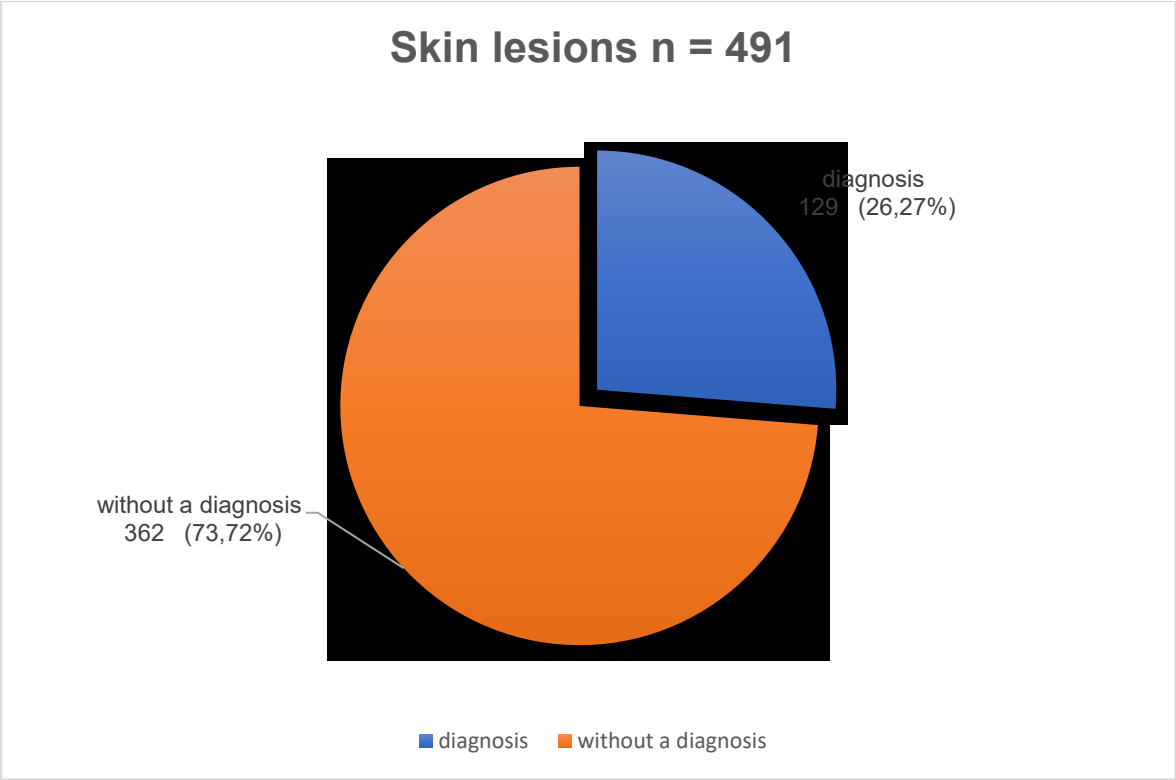

Figure 7. *General data - overview of skin lesions with/without a given diagnosis from the general practitioner*

The general practitioners diagnosed 129 skin lesions. Actinic keratosis, tinea corporis and seborrheic keratosis were the most suggested diagnoses (Table 4).

The two dermatologists, who worked as teleconsultants, telediagnosed 476 skin lesions with a primary diagnosis. Nevus, seborrheic keratosis and contact dermatitis were the most chosen primary diagnoses (Table 5). In 15 medical cases they were not able to make a primary diagnosis and used the term “tumor” and recommend a face-to-face consultation or excision. In certain cases, they additionally offered differential diagnoses (Table 6).

Number of requested diagnoses	Diagnoses of the general practitioner
11	Actinic keratosis
9	Tinea corporis
8	Onychomycosis, Seborrheic keratosis
7	Erythema migrans, Herpes zoster, Scabies,
6	Acne vulgaris, Contact dermatitis (toxic, allergic), Basal cell carcinoma,
5	Perioral dermatitis, Nevus
4	Drug eruption
3	Pityriasis rosea, Herpes simplex, Impetigo contagiosa
2	Rosacea, Melanoma, Viral rash, Arthropod reaction, Rhinophym,
1	Seborrheic eczema, Erysipelas, Squamous cell carcinoma, Lentigo maligna, Hemangioma, Atheroma, Mycosis fungoides, Ringlet rubella, Pityriasis versicolor, Desiccation eczema, Erythema nodosum, Hirsutis papillaris penis, Diaper rash, Vasculitis, Thrombophlebitis, Ulcus cruris, Dermatofibroma, Verruca vulgaris, Fibroma pendulans, Postherpetic neuralgia, Dyshidrotic eczema,

Table 4. *Diagnoses of the General practitioners*

Number of diagnoses	Diagnoses of the two teleconsultants (dermatologists)
48	Nevus
40	Seborrheic keratosis
30	Contact dermatitis (toxic, allergic)
29	Actinic keratosis
19	Tinea corporis,
16	Rosacea
15	Basal cell carcinoma,
14	Atopic dermatitis,
13	Arthropod reaction, Desiccation dermatitis, Stasis dermatitis
10	Squamous cell carcinoma, Dermatofibroma, Erythema migrans,
9	Seborrheic eczema, Psoriasis vulgaris
8	Acne vulgaris,
7	Viral rash, Hemangioma, Lentigo solaris, Onychmycosis,
6	Nummular eczema, Pityriasis rosea, Urticaria, Perioral Dermatitis,
5	Folliculitis, Granuloma anulare, Herpes simplex, Drug eruption, Pityriasis versicolor,
4	Lupus (cutaneous), Scabies,
3	Impetigo contagiosa, Chondrodermatitis nodularis helicis, Herpes zoster, Prurigo nodularis, Vasculitis, Rhinophym, Verruca vulgaris, Onchydystrophy, Traumata, Chronic sun-damaged skin
2	Dyshidrotic eczema, Mycosis fungoides, Fixed drug eruption, Lichen simplex chronicus, Erysipelas, Scratches, Acne neonatorum, Lymphoma, Keratoacanthoma, Purpura pigmentosa progressive, Phototoxic reaction,
1	Atheroma, Akanthoma, Post-scabious eczema, Lentigo maligna, Ulcus cruris, ILVEN, Eyelid eczema, Raynaud syndrome, Congelatio, Lichen ruber, Paronychia, Dorsal fingercyst, Morphea, Dermatitis pratensis, Notalgia paraesthetica, Post-zoster neuralgia, Occlusive folliculitis, Mucoid cyst, Scar, Cold panniculitis, Melanoma, Canker rash, Hämatoma, Hypersensitivity reaction, Chicken pox, Hirsutis

	papillaris penis, Pruritus, Onychochisis, Thrombophlebitis, Lichen sclerosus,

Table 5. *Diagnoses of the teledermatologists*

Number of differential diagnoses	**Differential diagnoses of the two teleconsultants (dermatologists)**
16	Contact dermatitis (toxic, allergic)
9	Arthropod reaction,
8	Squamous cell carcinoma, Tinea corporis,
7	Basal cell carcinoma,
6	Erythema migrans,
4	Atopic eczema, Psoriasis, Desiccation dermatitis, Drup eruption,
3	Nevus, Folliculitis, Stasis dermatitis, Actinic keratosis, Viral rash, Urticaria, Seborrheic eczema, Melanoma, Spitz Nevus,
2	Granuloma anulare, Dyshidrotic eczema, Prurigo, Onychomycosis,
1	Polymorph light dermatosis, Furunkel, Erysipelas, Sweet syndrome, Sarcoidosis, perioral dermatitis, Rosacea, Lupus, Atheroma, Morphea, Chondrodermatitis nodularis helicis, Purpura pigmentosa progressiva, Thrombophlebitis, Scar, Trauma, Acne neonatorum, Onychodystrophy,

Table 6. *Differential diagnoses of the teledermatologists*

3.2. Dermoscopy to diagnostic accuracy in the research project "Teledermatology Styria"

The general practitioners documented 307 skin lesions with a dermatoscopic image as medical cases. The author changed his primary clinical diagnosis in 9.44% (29/307) of the medical cases, because of the dermatoscopic image. These 29 medical cases included 28 single skin lesions and one rash.

The primary clinical diagnoses of the skin lesions were melanoma, nevus, basal cell carcinoma, seborrheic keratosis, actinic keratosis, dermatofibroma, lentigo maligna, folliculitis, hematoma and prurigo nodularis. Melanoma was the clinically most common suspected skin lesion, which was changed by the author due to dermoscopy. In six times the clinically diagnosed melanoma was identified as a nevus by dermatoscopy. Two examples are demonstrated in Figure 8 and 9. The other three clinically suspect melanomas were detected as lentigo maligna, seborrheic keratosis (Figure 10) and hemangioma. For comparison, Figure 11 shows the tenth clinically suspect melanoma for the author, which has been confirmed by dermoscopy. Basal cell carcinoma was the second most frequent clinically suspect diagnosis, which was changed in six times. The diagnosis of basal cell carcinoma was changed to two seborrheic keratosis, to two nevi, one actinic keratosis and one ulcus. Five nevi changed to seborrheic keratosis in three times and to dermatofibroma in two times (Figure 12). Three seborrheic keratosis were classified as two nevi and one as basal cell carcinoma by dermoscopy. One actinic keratosis and one dermatofibroma changed to a seborrheic keratosis each. One lentigo maligna was corrected to an actinic keratosis and a hematoma to a dermatofibroma. A brown to red stain, imitating a folliculitis, was identified as a dermatofibroma. A rash, which was clinical suspect for a prurigo nodularis, revealed as scabies because of the jet stream sign, which was seen in the dermatoscope. The author's primary clinical diagnoses of the skin lesions and the corresponding teledermatoscopic diagnoses are summarized in Table 7.

Skin lesions clinically suspected for:	Teledermatoscopic diagnoses
9 Melanomas	6 Nevi, 1 Lentigo maligna, 1 Seborrheic keratosis, 1 Hemangioma
6 Basal cell carcinomas	2 Seborrheic keratoses, 2 Nevi, 1 Actinic keratoses, 1 Ulcus
5 Nevi	3 Seborrheic keratoses, 2 Dermatofibromas,
3 Seborrheic keratoses	2 Nevi, 1 Basal cell carcinoma
1 Actinic keratosis	1 Seborrheic keratosis
1 Dermatofibroma	1 Seborrheic keratosis
1 Lentigo maligna	1 Actinic keratosis
1 Folliculitis	1 Dermatofibroma
1 Hematoma	1 Dermatofibroma
1 Prurigo nodularis	1 Scabies

Table 7. *The author's 29 primary clinical diagnoses opposed to their 29 dermatoscopic diagnoses*

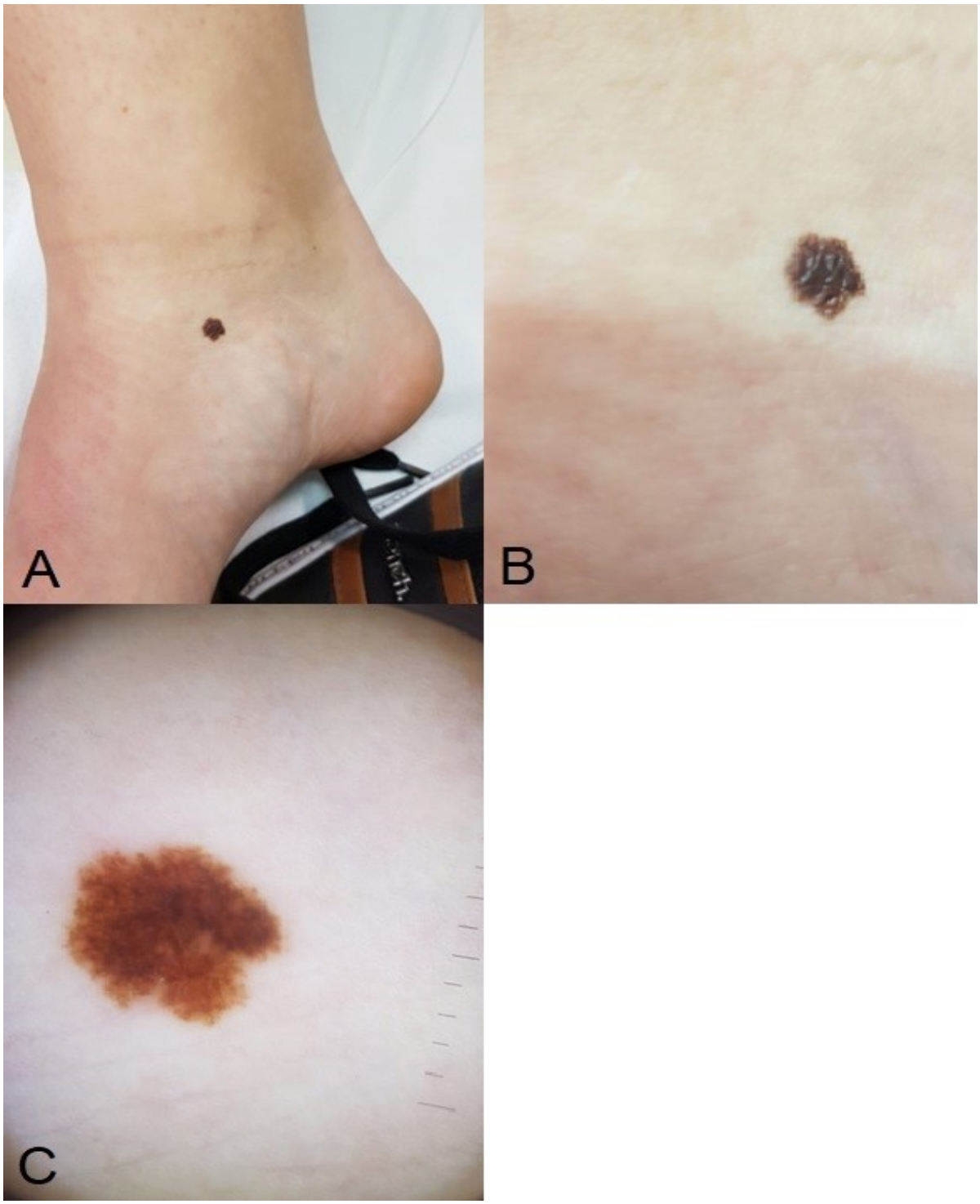

Figure 8. *Clinically suspect for a melanoma I*

(A) Clinical image overview: a single, large, dark pigmented, irregular shaped lesion on the medial right ankle of a 35 years old woman - suspect for a melanoma (B) Clinical view detail (C) Dermatoscopic view: light brown, regular pigment network - suitalbe for a nevus

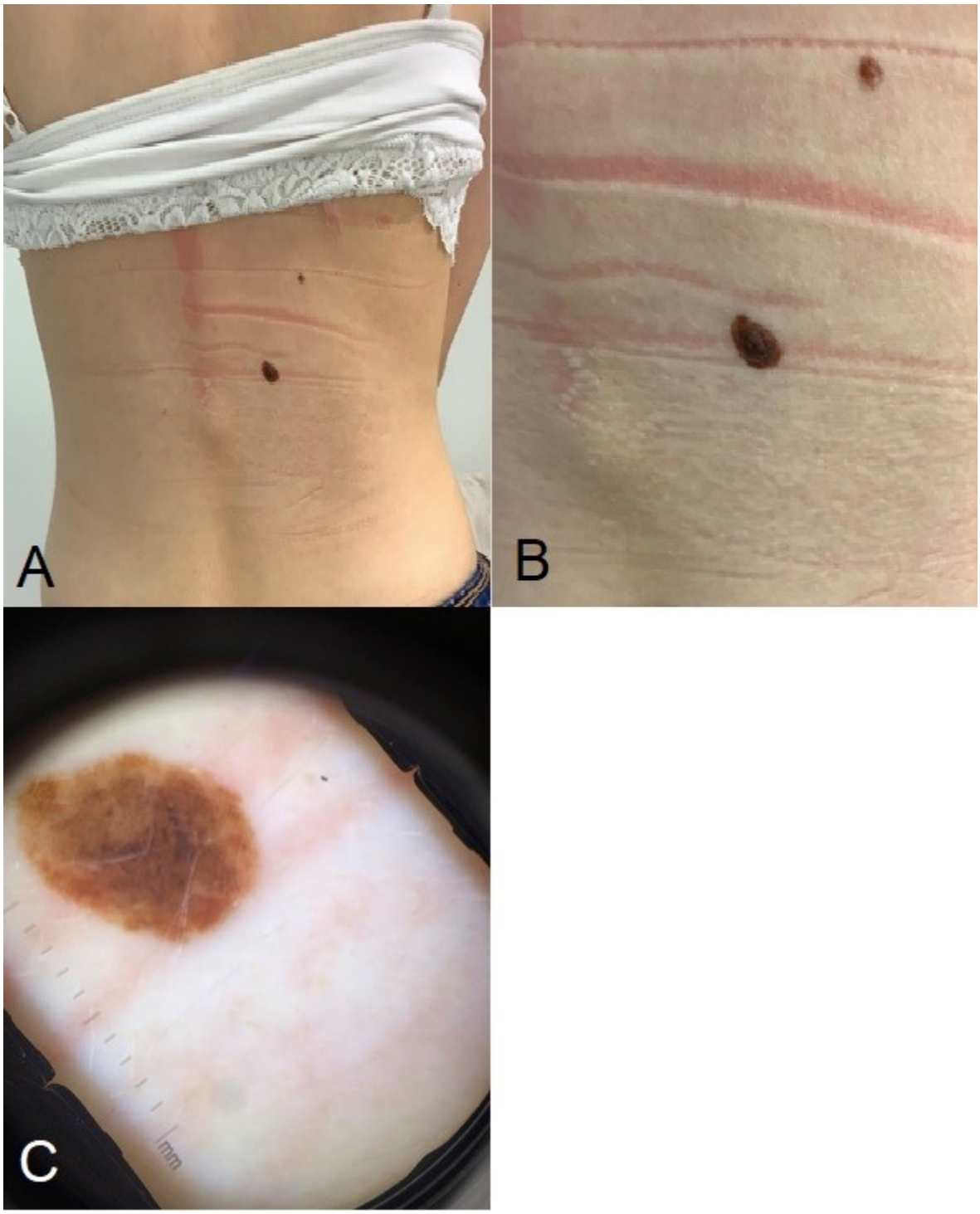

Figure 9. *Clinically suspect for a melanoma II*

(A) Clinical image overview: a single, large, oval, dark pigmented lesion on the back of a 30 years old woman - suspect for melanoma (B) Clinical view detail: a single, large, oval, dark pigmented lesion with a nodular part in the center (C) Dermatoscopic view: 8mm in diameter, structureless in the periphery and regular globules in the centre - suitable for a congenital nevus

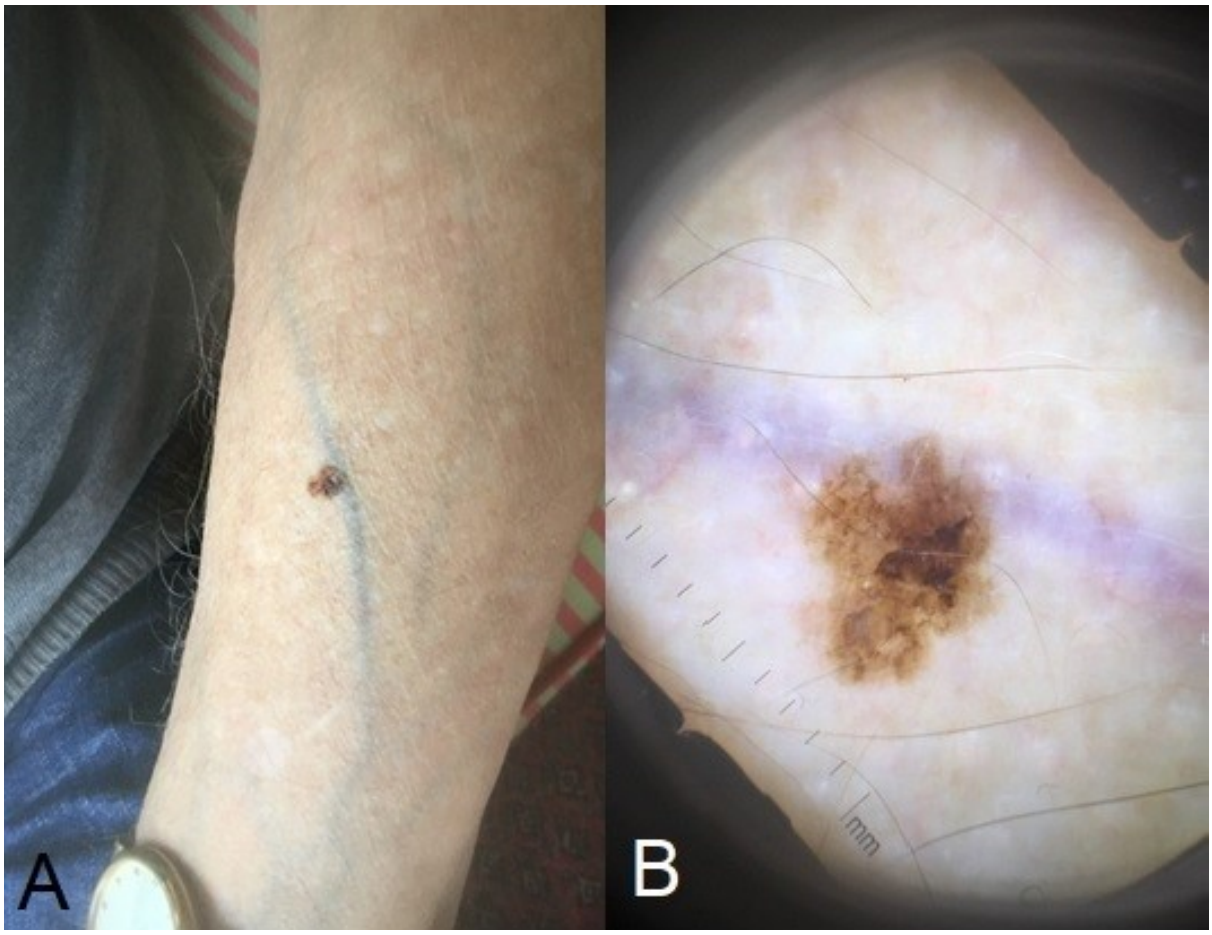

Figure 10. *Clinically suspect for a melanoma III*

(A) Clinical image detail: single, small, dark pigmented, irregular shaped skin lesion on the left forearm of a 60 years old man - suspect for a melanoma (B) Dermatoscopic view: 6mm in diameter, light brown pigment network - suitable for a seborrheic keratosis

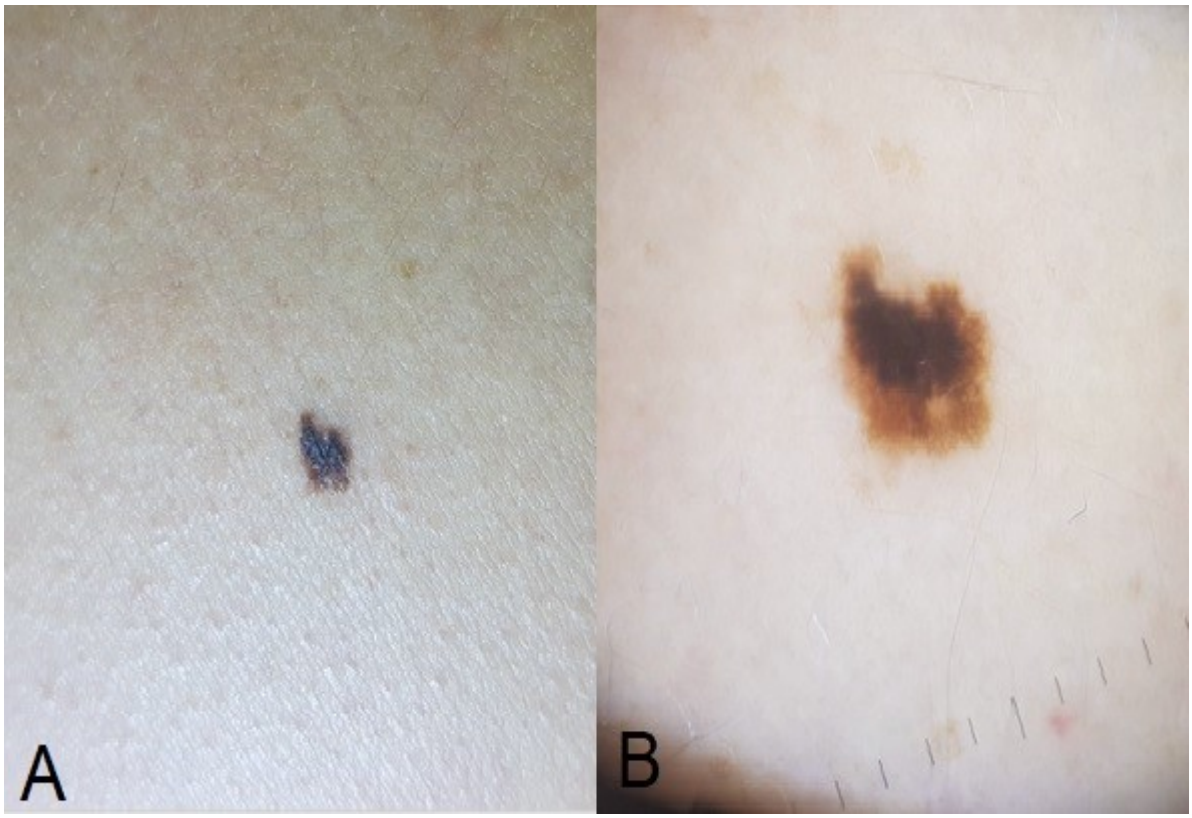

Figure 11. *Clinically suspect for a melanoma IV*

(A) Clinical image detail: small, dark pigmented, irregular shaped skin lesion on the abdomen of a 45 years old woman – clinically suspect for a melanoma (B) Dermatoscopic view: eccentric, dark brown structureless area mainly surrounded by a light brown pigment network – suspect for a melanoma DD dysplastic nevus – recommendation of the teleconsultant to excise the lesion

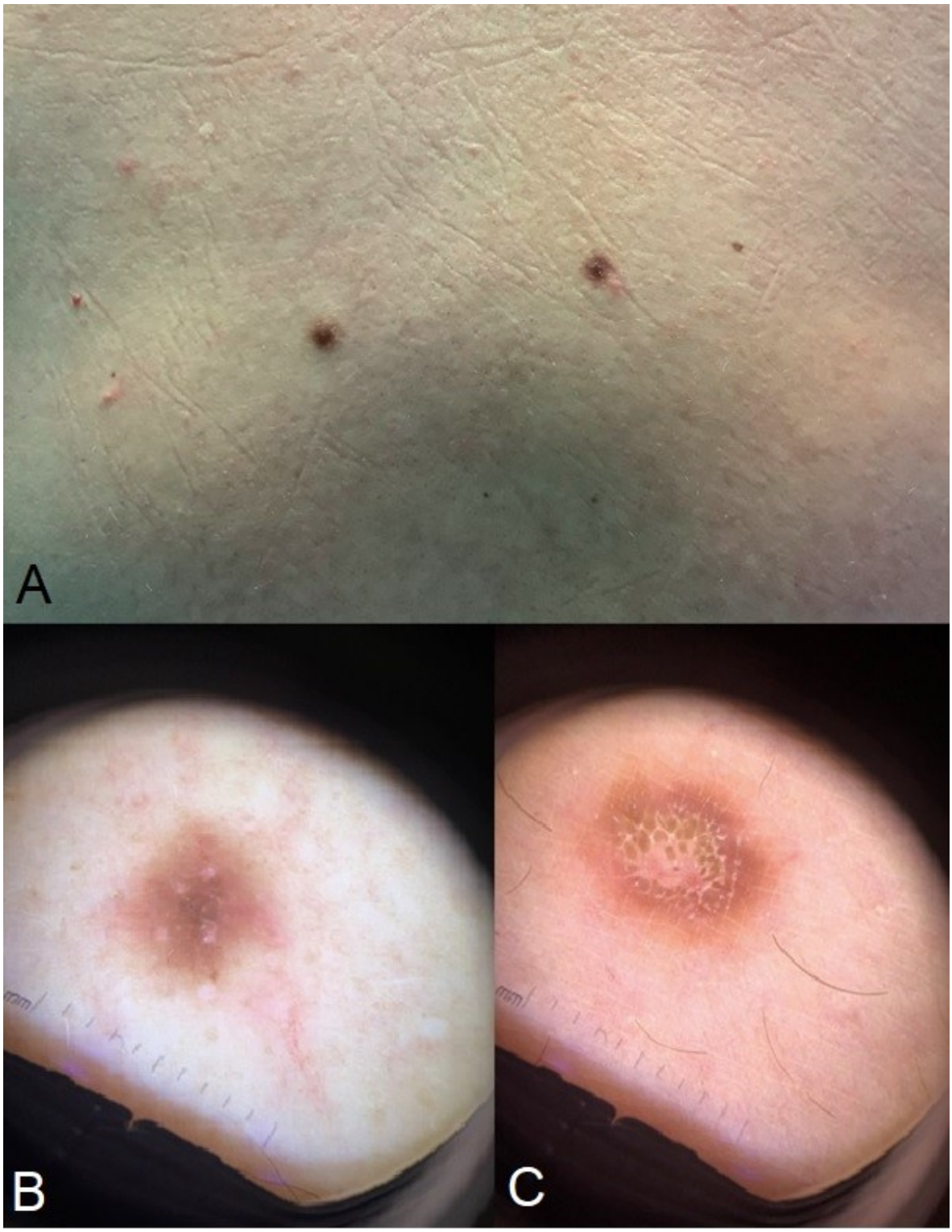

Figure 12. *Clinically suspect for two nevi*

(A) Clinical image two brown pigmented lesions on the back of a 40 years old man - clinically suspect for two nevi (B) + (C) Dermatoscopic view: central structureless area with a delicate pigment network at the periphery - suitable for two dermatofibromas

The author changed his primary clinical diagnosis 12 times, because of the medical history, which was documented by the general practitioner. Resulting, that medical history changed primary clinical diagnosis in 3,90% (12/307) of the medical cases. According to that 12 medical cases, the clinical diagnoses of the skin lesions were urticaria, atopic dermatitis, cutaneous lupus, strophulus infantum, erysipelas, arthropod reaction, scabies, contact dermatitis, drug eruption and porphyria. In one case the author was not able to make a diagnosis with the clinical image, but was able to diagnose a post zoster neuralgia after reading the patient's history. Urticaria was interpreted as a drug eruption after getting to know the medical history. Atopic dermatitis changed to post-scabious eczema twice, because of scabies in the patient's history. Clinical diagnosis of erysipelas was changed to contact dermatitis, because there were no systemic reactions like fever. Strophulus infantum was corrected to hypersensitivity reaction, because a vaccination for measles was documented in the medical history.

Skin lesions clinical suspicious for	**Diagnosis with medical history**
Urticaria	Drug eruption
Atopic dermatitis	Post-scabious eczema
Cutaneous lupus	Urticaria
Strophulus infantum	Hypersensitivity reaction
Erysipelas	Contact dermatitis
Atopic dermatits	Post-scabious eczema
Arthropod reaction	Herpes Zoster
Scabies	Atopic dermatitis
Porphyria	Dermatitis pratensis
no diagnosis	Post zoster neuralgia
Contact dermatitis	Psoriasis vulgaris
Drug eruption	Phototoxic reaction

Table 8. *The author's primary clinical diagnosis, which have been changed because of medical history*

3.3. Subgroup analysis of dermoscopy in single skin lesions to diagnostic accuracy

The study population included 168 single skin lesions with clinical and dermatoscopic images, which were primarily suspicious for a skin neoplasm. In 19 cases, the quality of the dermatoscopic images was too low to provide a dermatoscopic diagnosis, because the general practitioners misapplied the dermatoscope. The family doctors used too much pressure when placing the dermatoscope on the skin or overexposed the pictures. The diagnoses of these skin lesions were based on the clinical images combined with the anamneses and were recommended for excision or for in-person consultations. 149 skin lesions were diagnosed with the support of the dermatoscopic image (Table 9). The diagnostic accuracy of the author increased from 72,02% to 88,69% with a dermatoscopic image for single skin lesions, that were primarily suspicious for cutaneous neoplasms.

Author's primary clinical diagnosis	**Author's dermatoscopic diagnosis**	**Diagnosis of teledermatologist**
40 Nevi	45 Nevi	45 Nevi
31 Seborrheic keratoses	36 Seborrheic keratoses	36 Seborrheic keratoses
19 Actinic keratoses	20 Actinic keratoses	20 Actinic keratoses
16 Basal cell carcinomas	11 Basal cell carcinomas	11 Basal cell carcinomas
7 Dermatofibromas	10 Dermatofibromas	10 Dermatofibromas
7 Lentigo solaris	7 Lentigo solaris	7 Lentigo solaris
5 Hemangiomas	6 Hemangiomas	6 Hemangiomas
4 Squamous cell carcinomas	4 Squamous cell carcinomas	4 Squamous cell carcinomas
3 Verruca vulgares	3 Verruca vulgares	3 Verruca vulgares
2 Chondrodermatitis nodularis helicis	2 Chondrodermatitis nodularis helicis	2 Chondrodermatitis nodularis helicis
2 Keratoacanthomas	2 Keratoacanthomas	2 Keratoacanthomas
10 Melanomas	1 Melanoma	1 Melanoma
1 Lentigo maligna	1 Lentigo maligna	1 Lentigo maligna
1 Hematoma	1 Ulcus	1 Ulcus
1 Folliculitis		

Table 9. *Overview of the author's primary and dermatocopic diagnosis*

3.4. Diagnostic accuracy of the general practitioner

The general practitioners requested 26,27% (129/491) of the medical cases with a diagnosis in that teledermatology programme. The teledermatologist confirmed in 62,01% (80/129 skin lesions) the general practitioner's diagnoses of the medical cases. The most correct diagnoses were actinic keratosis, erythema migrans, fungal infections, acne vulgaris and seborrheic keratosis (Table 10).

Number of diagnoses	Diagnosis
10	Actinic keratosis
6	Erythema migrans, Onychomycosis, Tinea corporis, Acne vulgaris, Seborrheic keratosis
4	Contact dermatitis
3	Herpes Zoster, Perioral Dermatitis
2	Herpes simplex, Rosacea, Nevus, Rhinophyma, Basal cell carcinoma, Pityriasis rosea
1	Dyshidrotic eczema, Mycosis fungoides, Post-herpetic neuralgia, Hemangioma, Vasculitis, Pityriasis versicolor, Squamous cell carcinoma, Hirsutis papillaris penis, Atheroma, Arthropod reaction, Desiccation eczema, Thrombophlebitis, Impetigo contagiosa, Lentigo maligna, Scabies, Ulcus cruris, Viral rash, Drup eruption

Table 10. *Diagnoses of the General practitioners, which have been confirmed by the teledermatologists*

4. Discussion

Teledermatology became very popular over the last years and is frequently used in different medical institutions in many countries all over the world nowadays, especially during the COVID 19 pandemic (14) (15). Telemedicine makes it possible for remote people to have excess to special medicine. Published literature supports, that teledermatology reduces waiting times and in-dermatologist consultations, as well as improving patient's satisfaction (16) (17). At the same time the cost saving aspect of teledermatology is an additional advantage for the societal and healthcare sector (8). All these benefits have to be put in relation to the reliability of teledermatology in comparison to clinical dermatology according to the discussion to implement teledermatology as a medical care service (8) (17).

The diagnostic accuracy rate in teledermatology seems to range widely. While a few studies describe inferior and even superior diagnostic accuracy rates of teledermatology compared to clinical dermatology, the majority of the studies support diagnostic accuracy rates, which approach face-to-face dermatological consultations (8) (12). In a review article from 2011 including 78 studies Warshaw et al. described that teledermatology was inferior to clinical dermatology, but teledermatoscopy rised the diagnostic accuracy rates in teledermatology up to 15% for pigmented and nonpigmented lesions (18). Senel et al. examined 150 patients with non-melanocytic skin tumours via store-and-forward teledermatology and could show, that the diagnostic accuracy rates of the two teledermatologists significantly rised (from 85% to 94% and 88% to 95%) through a dermatoscopic image (19). An additional dermatoscopic image improved sensitivity and specificity (from 86,57% and 72,33% to 92,86% and 96,24%) in clinical teleconsultations in Ferrandiz et al. trial for skin cancer screening with 454 people (20).

The author's primary clinical diagnosis was changed by an additional dermatoscopic images in 29 times out of 307 medical cases in that store-and-forward teledermatology delivery system. These 29 final diagnoses of the author and the two teledermatologists were found for complete agreement, resulting in a higher diagnostic accuracy in the authors decision-making process.

28 of these skin lesions were single skin lesions, which were primarily suspected for pigmented and nonpigmented skin neoplasm. We affiliated a subgroup analysis of 168 single skin lesions, which were primarily suspected for cutaneous neoplasms and were able to show, that the author's diagnostic accuracy rate improved from 72,02% to 88,69%, which is comparable to the published literature mentioned above.

Dermatoscopic images were found to be useless in the diagnostic process in 11,08% (19/168) in that population. The majority of the images showed a too poor quality, which was due to incorrect use of the dermatoscopes. The main reason was, that the general practitioner applied to much pressure on the skin when using the dermatoscope distinguishing important dermatoscopic criteria. Secondly, some pictures were overexposed. Two skin lesions did not offer any criteria at dermatoscopic view for the diagnostic process regardless of picture quality.

In the remaining 139 medical cases concerning inflammatory diseases and infestations, the author's primary clinical diagnosis was changed by dermoscopy only once. In this specific medical case, which was clinically suspected for a pruritic disease, primarily prurigo nodularis (DD premonitory bullous pemphigoid), the diagnosis was changed to scabies because of the jet stream sign, dedicated by dermoscopy. The majority of the dermatosopic pictures of that subgroup were found to show mediate to good quality. Regardless of picture quality, in our experience dermatoscopic pictures of a rash, occurring on several body parts, gave too little or no more information, than could already be determined by teleconsultation with clinical images. In the published literature there are no studies examining the benefit of teledermatoscopy in the diagnostic accuracy for inflammatory disease and infestations or even trichoscopy.

The author changed his primary clinical diagnosis only in 12 times because of medical history without the support of dermoscopy in these 139 medical cases, concerning general dermatology. Medical histories gave no detailed information, which could have been important in the dermatological diagnostic process. Mostly they were limited to lifespan of a skin change, but didn't include any further information like: itching or burning sensations, recurring skin changes, systemic symptoms, anybody else affected and further characteristics. We could image, that a special questionnaire with

detailed dermatological questions concerning rashes could improve the contribution of the medical history in teleconsultations.

In our opinion it seems that single skin lesions can be easier documented by medical history and better pictured for dermatoscopic evaluation than skin conditions concerning general dermatology, in particular rashes.

While the diagnostic accuracy of teledermatology is comparable to face-to-face consultations, interobserver diagnostic agreements vary from 21% to 60% between general practitioners and teledermatologists (12). In our study the general practitioner requested 491 skin lesions and were able to make a diagnosis. In 73,72% (362/491) of the skin lesions they requested the medical cases without giving a diagnosis. In the remaining 129 medical cases the general practitioner's diagnoses were confirmed by the teledermatologist in 80 times. Because of the high number of undiagnosed medical cases we conclude, that there is a demand for dermatological consultations for general practitioners. Secondly, we could detect, that the general practitioner made the correct diagnosis in nearly 62,01% (80/129) and support the opinion, that diagnostic accuracy of teledermatology overcomes general practice, in the case of insufficient dermatological training (11).

Limitations of the masterthesis are the small number of study population and the teledermatologist's diagnoses as reference test, compared to histopathology mainly for biopsied skin lesions or in-dermatologist visits as reference test in the recent literature (21) (19).

A recommendation for diagnosing skin cancer cannot be derived from the available data concerning diagnostic accuracy of teledermatology according to a Cochrane review in 2018 (22). Suggestions are, that teledermatology can be used additional for referral and triage purposes (17).

5. Conclusion

Dermoscopy rised the diagnostic accuracy rate for single skin lesions, which were primarily suspected for cutaneous neoplasms. Dermatoscopic images didn´t offer any further information than the naked eye examination of skin changes concerning general dermatology, for example rashes. Single skin lesions can be better documented for dermatoscopic evaluation than rashes. Medical history only had a small impact in the decision-making process in the clinical teleconsultations. Diagnostic accuracy of general practitioners was lower than the teledermatologists. The number of undiagnosed requests indicates the need for teledermatology consultations.

6. Appendix

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6.2. Table of figures

6.3. List of tables