

**TELEDENTISTRY TEXNOLOGIYALARINING STOMATOLOGIK
KASALLIKLARNI MASOFADAN TASHXISLASH VA BEMORLARNI
KUZATISHDAGI SAMARADORLIGI**

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ANNOTATSIYA

Maqolada teledentistry texnologiyalarining stomatologik kasalliklarni masofadan tashxislash, triage qilish va bemorlarni longitudinal kuzatishdagi samaradorligi zamonaviy dalillar asosida baholandi. Tadqiqot birlamchi klinik tajriba emas, balki 2023–2026-yillardagi systematic review, meta-analysis, umbrella review va O'zbekistonning raqamli sog'liqni saqlash hamda stomatologik texnologiyalar bo'yicha manbalariga tayangan ikkilamchi dalillar sintezidir. 2025-yilgi klinik fotografiya meta-tahlilida 18 tadqiqot va 1300 ishtirokchi bo'yicha emal kariyesini fotosuratdan aniqlashda pooled sezgirlik 0,74 va spetsifiklik 0,95, dentin kariyesida 0,81 va 0,98, har qanday kariyes chuqurligida 0,81 va 0,99 bo'lgan. 2023-yilgi oral lesions meta-analysisda 3783 bemor asosida teledentistry orqali og'iz lezyonlarini aniqlash sezgirligi/spetsifikligi taxminan 0,92/0,93, differensial tashxisda esa 0,942/0,982 ga yetgan. Ortodontik monitoring meta-tahlili masofaviy Dental Monitoring® tizimi aligner terapiyasida yuzma-yuz tashriflar sonini o'rtacha 2,75 taga va refinement boshlanish vaqtini 1,21 birlikka kamaytirganini ko'rsatgan, biroq dalil ishonchliligi juda past deb baholangan. 2025-yilgi 30 systematic reviewni qamrab olgan overview teledentistry samaradorlik, patient-centered care va efficiency bo'yicha ijobiy natijalar ko'rsatishini, 9 sharhda access inequities kamayishi qayd etilganini bildirgan. Biroq image quality, diagnostic threshold, internet infratuzilmasi, data privacy, legal responsibility va uzoq muddatli cost-effectiveness bo'yicha muammolar mavjud. Teledentistry eng maqbul holda yuzma-yuz stomatologiyani almashtiruvchi emas, balki triage, screening, monitoring va follow-upni kuchaytiruvchi gibrid xizmat modeli sifatida ishlatilishi kerak.

Kalit soʻzlar: teledentistry, telemeditsina, masofaviy tashxis, stomatologik monitoring, kariyes, oral lezyonlar, ortodontik kuzatuv, smartphone fotografiya, teleconsultation, raqamli stomatologiya.

АННОТАЦИЯ

В статье оценивается эффективность технологий телестоматологии для дистанционной диагностики стоматологических заболеваний, триажа и длительного наблюдения пациентов. Работа представляет собой синтез систематических обзоров, метаанализов и umbrella-review 2023–2026 гг. В метаанализе 2025 года, включавшем 18 исследований и 1300 участников, чувствительность/специфичность клинической фотографии составили 0,74/0,95 для кариеса эмали, 0,81/0,98 для кариеса дентина и 0,81/0,99 для кариеса любой глубины. В метаанализе поражений слизистой полости рта телестоматология показала чувствительность около 0,92 и специфичность 0,93, а для дифференциальной диагностики — 0,942 и 0,982. При ортодонтическом мониторинге дистанционные технологии уменьшали количество очных визитов в среднем на 2,75 и ускоряли начало refinement, хотя достоверность доказательств была очень низкой. Телестоматология особенно перспективна для скрининга, консультаций, наблюдения и повышения доступности стоматологической помощи, однако требует стандартизации изображения, защиты данных и четких критериев направления на очный прием.

Ключевые слова: телестоматология, телемедицина, дистанционная диагностика, стоматологический мониторинг, кариес, поражения слизистой, ортодонтия, фотография смартфоном, телеконсультация, цифровая стоматология.

ABSTRACT

This article evaluates the effectiveness of teledentistry technologies for remote diagnosis, triage, and longitudinal monitoring of dental patients. The study is a secondary evidence synthesis based on systematic reviews, meta-analyses, umbrella reviews published between 2023 and 2026, together with selected Uzbek literature on digital health and dentistry. A 2025 systematic review and meta-analysis of 18 studies involving 1,300 participants reported pooled sensitivity/specificity of 0.74/0.95 for enamel caries, 0.81/0.98 for dentine caries, and 0.81/0.99 for caries at any depth when clinical photographs were assessed remotely. A diagnostic meta-analysis of oral lesions found teledentistry sensitivity/specificity of approximately 0.92/0.93 for lesion detection and 0.942/0.982 for differential diagnosis. A systematic review and meta-analysis of orthodontic monitoring showed a mean reduction of 2.75 face-to-face appointments and an earlier start of refinement

by 1.21 units in aligner patients, although the certainty of evidence was very low. A 2025 overview of 30 systematic reviews found teledentistry most frequently associated with effectiveness, patient-centered care, efficiency, and improved access for vulnerable or remote populations. Nevertheless, diagnostic performance depends strongly on image quality, lesion type, diagnostic criteria, connectivity, patient digital literacy, privacy safeguards, and clinician experience. Teledentistry should therefore be implemented primarily as a hybrid model supporting screening, triage, monitoring and follow-up rather than as a universal substitute for in-person dental examination.

Keywords: teledentistry, telemedicine, remote diagnosis, dental monitoring, dental caries, oral lesions, orthodontic monitoring, smartphone photography, teleconsultation, digital dentistry.

KIRISH

Teledentistry — stomatologik xizmat ko'rsatuvchi mutaxassis va bemor yoki boshqa tibbiy mutaxassislar o'rtasida masofa mavjud bo'lgan sharoitda axborot-kommunikatsiya texnologiyalari orqali oral healthcare xizmatlarini taqdim etish shaklidir. U synchronous video consultation, asynchronous store-and-forward imaging, tele-triage, tele-diagnosis, tele-monitoring va tele-education komponentlarini qamrab oladi.

Teledentistry ayniqsa geografik jihatdan uzoq hududlar, stomatolog mutaxassislar yetishmaydigan joylar, qariyalar uylari, maktablar, maxsus ehtiyojli bemorlar va tez triage talab qilinadigan vaziyatlarda muhim. Smartphone kamerasi, intraoral kamera va secure messaging platformalari masofadan klinik tasvirlarni olish va stomatologga yetkazishni osonlashtirdi.

Masofaviy tashxisning klinik qiymati an'anaviy yuzma-yuz ko'rik bilan diagnostik concordance orqali baholanadi. Kariyes, oral mucosal lesion, oral potentially malignant disorder, postoperative wound, orthodontic progress va emergency triage teledentistryda eng ko'p o'rganilgan yo'nalishlar hisoblanadi.

2025-yilgi Journal of Medical Internet Research overview 30 systematic reviewni qamrab olib, teledentistryning effectiveness 22/30 sharhda, patient-centered care 14/30 va efficiency 11/30 sharhda o'rganilganini ko'rsatdi. To'qqiz sharh vulnerable guruhlar uchun access-to-care va inequity kamayishini qayd etgan.

Teledentistry tashxisning aniqligini oshirmaydi, agar tasvir sifati past bo'lsa. Yoritish, fokus, kamera resolutsiyasi, retraksiya, saliva, posterior sohalarga yetib borish va diagnostic

thresholdlar sezgirlikni keskin o'zgartirishi mumkin. Shu sababli uning samaradorligi texnologiya nomidan ko'ra implementation protocolga kuchliroq bog'liq.

Kariyes bo'yicha 2024-yilgi systematic review 19 in-vivo tadqiqotni kiritgan va sensitivity 48–98,3%, specificity 83–100% oralig'ida ekanini ko'rsatgan. 2025-yilgi meta-tahlil esa ushbu heterojenlikni pooled diagnostik qiymatlar bilan aniqroq ifodaladi.

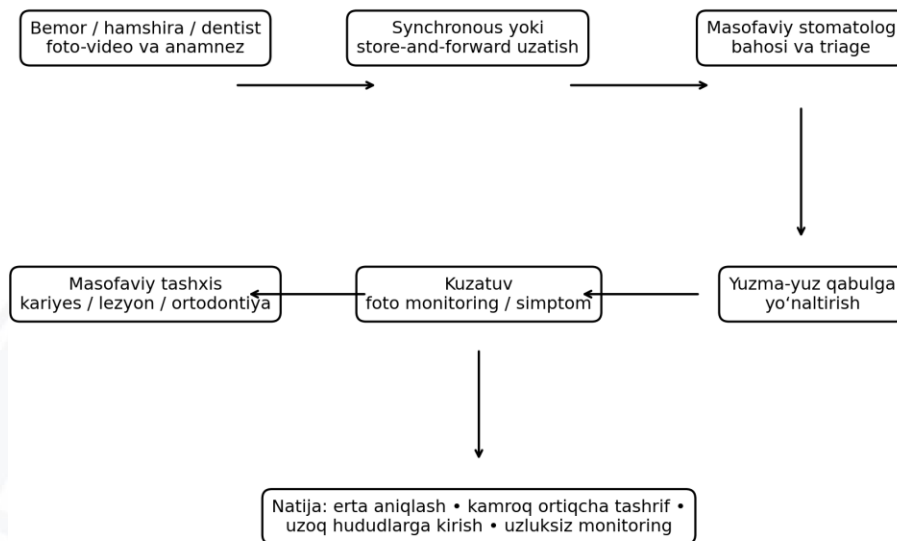
Oral medicine sohasida teledentistry oral lesions va oral potentially malignant disordersni erta aniqlashga yordam beradi. High specificity referral tizimini yaxshilashi mumkin, lekin suspicious lesion biopsiya yoki klinik palpatsiyani talab qilishi sabab masofaviy tashxis yakuniy histopathological diagnosisni almashtirmaydi.

Ortodontiyada teledentistry treatment progressni foto/video yoki maxsus monitoring platformalari orqali kuzatish imkonini beradi. Bu aligner tracking, attachment loss, appliance fit va oral hygiene monitoringda yuzma-yuz tashriflarni optimallashtirishi mumkin.

O'zbekistonda telemeditsina va raqamli sog'liqni saqlash bo'yicha ilmiy nashrlar masofaviy maslahat, monitoring, maxfiylik va texnologik cheklovlarni tahlil qilmoqda. Stomatologiyada ham AI, raqamli diagnostika va treatment monitoring bo'yicha mahalliy ishlar paydo bo'lmoqda, bu teledentistry uchun metodologik asos yaratadi.

Tadqiqotning maqsadi teledentistry texnologiyalarining stomatologik kasalliklarni masofadan aniqlash va bemorlarni kuzatishdagi klinik samaradorligini tizimlashtirish, kariyes, oral lesions, ortodontiya va access-to-care bo'yicha kvantitativ natijalarni qiyoslash hamda xavfsiz gibril klinik modelni taklif etishdan iborat.

Teledentistry orqali masofaviy tashxis va monitoring modeli



1-rasm. Teledentistry orqali masofaviy tashxis, triage va monitoringning klinik modeli.

Asosiy qism

Ushbu maqola birlamchi klinik tajriba emas, balki ikkilamchi dalillar sintezidir. Ustuvor manbalar sifatida 2023–2026-yillardagi teledentistry systematic review va meta-analysislar, umbrella-reviewlar, diagnostic accuracy sharhlari va O'zbekistonning telemeditsina hamda digital dentistry bo'yicha nashrlari olindi.

Natijalar to'rt domen bo'yicha tahlil qilindi: masofaviy kariyes diagnostikasi; oral soft-tissue va potentially malignant lesion diagnostikasi; ortodontik va boshqa longitudinal monitoring; access, efficiency, satisfaction va cost-related outcomes.

Kariyes diagnostikasiga oid 2024-yilgi systematic reviewda 709 topilma aniqlanib, 19 in-vivo tadqiqot kiritilgan. Sensitivity 48–98,3%, specificity 83–100%, inter-examiner kappa 0,44–0,91 va intra-examiner kappa 0,52–1,00 oralig'ida bo'lgan. Heterojenlik sabab meta-analysis o'tkazilmagan.

2025-yilgi clinical photography systematic review va meta-analysis 18 tadqiqot va 1300 ishtirokchini qamrab olgan. Emal kariyesi uchun pooled sensitivity 0,74 va specificity 0,95; dentin kariyesi uchun 0,81 va 0,98; any caries depth uchun 0,81 va 0,99 bo'lgan. Smartphone camera va intraoral camera o'rtasida performance farqi statistik jihatdan aniqlanmagan.

Oral lesions diagnostic meta-analysisda uch tadqiqot va 3783 bemor bo'yicha lesion detection sensitivity taxminan 0,92, specificity 0,93 bo'lgan. Differential diagnosisda pooled sensitivity 0,942 va specificity 0,982 ga yetgan. Heterojenlik yuqori bo'lgani sabab natijalarni universal cutoff sifatida ishlatish mumkin emas.

Ortodontik monitoring systematic review 1178 yozuvdan 4 tadqiqotni tanlagan. Aligner tadqiqotlari meta-analysisida teledentistry yuzma-yuz tashriflar sonini MD $-2,75$ va refinement boshlanish vaqtini MD $-1,21$ ga kamaytirgan. Evidence certainty GRADE bo'yicha very low deb baholangan.

2025-yilgi access systematic review 46 tadqiqotni kiritib, teledentistry oral healthcare access, timely diagnosis, treatment planning va patient outcomesni yaxshilashga xizmat qilishi mumkinligini ko'rsatgan. 2025-yilgi overview esa 30 systematic review bo'yicha ushbu xulosani kengroq tasdiqlagan.

Cost-effectiveness bo'yicha dalil ancha zaif. 2024-yilgi umbrella review 10 reviewni kiritgan va ko'pchilik manbalarda teledentistry cost-saving deb tasvirlanganini, biroq bu xulosa ko'pincha assumptions va past sifatli observational dataga tayanganini qayd etgan.

Ma'lumotlar dalil ierarxiyasi asosida talqin qilindi: meta-analysis kvantitativ natijalarga ustuvorlik berildi, ammo bias, heterogeneity, small sample va low certainty ochiq ko'rsatildi. Teledentistry samaradorligi face-to-face diagnosis bilan equivalence yoki clinically acceptable concordance kontekstida baholandi.

Yo'nalish	Dalil bazasi	Asosiy natija	Klinik talqin
Kariyes: clinical photography	18 study; 1300 participant	Emal Se/Sp 0,74/0,95; dentin 0,81/0,98; any depth 0,81/0,99.	High specificity; erta emal lezyonlarida sensitivity pastroq.
Oral lesions	Meta-analysis; 3783 patient	Detection $\sim 0,92/0,93$; differential diagnosis 0,942/0,982.	Remote oral-medicine triage uchun kuchli signal.

Yo'nalish	Dalil bazasi	Asosiy natija	Klinik talqin
Orthodontic monitoring	4 controlled study	Appointments MD –2,75; refinement start MD –1,21.	Aligner follow-upni optimallashtirishi mumkin; certainty very low.
Access	46-study systematic review	Timely diagnosis, treatment planning va access yaxshilangan.	Uzoq va underserved hududlar uchun ayniqsa foydali.
Overview of reviews	30 systematic reviews	Effectiveness 22/30; patient-centered care 14/30; efficiency 11/30.	Teledentistry ko'p domenli foyda ko'rsatadi, evidence sifati turlicha.

1-jadval. Teledentistry samaradorligining asosiy dalillari.

XULOSA

Teledentistry stomatologik kasalliklarni masofadan screening, triage va monitoring qilishda klinik jihatdan samarali va istiqbolli vositadir.

Kariyesni klinik fotosuratlardan aniqlashda pooled specificity 0,95–0,99, sensitivity 0,74–0,81 diapazonida bo'lib, ayniqsa dentin va aniq lezyonlarda yuqori diagnostik ishonchlilik ko'rsatadi. Erta emal kariyesi uchun face-to-face/radiographic confirmation zarur bo'lib qoladi.

Oral soft-tissue lesionlarda teledentistry high sensitivity va specificity ko'rsatadi va specialist referral hamda oral-cancer triageni tezlashtirish imkonini beradi. Biroq biopsy va physical examinationni almashtira olmaydi.

Ortodontik masofaviy monitoring aligner bemorlarida yuzma-yuz tashriflarni o'rtacha 2,75 taga kamaytirishi va refinementni ertaroq boshlashga yordam berishi mumkin, lekin dalil ishonchliligi hozircha juda past.

Teledentistry access-to-care, travel burden, waiting time va patient convenience bo'yicha ijobiy natijalar ko'rsatadi. Cost-effectiveness esa hozircha yetarli yuqori sifatli iqtisodiy dalil bilan tasdiqlanmagan.

Teledentistry samaradorligining asosiy shartlari standardized imaging, secure data transfer, aniq escalation/referral criteria, clinician training va patient digital literacy hisoblanadi.

O‘zbekistonda teledentistry uchun eng maqbul boshlang‘ich yo‘nalishlar maktab skriningi, chekka hududlarda oral lesion/caries triage, orthodontic monitoring va postoperative follow-up bo‘lishi mumkin.

Kelgusida mahalliy ko‘p markazli tadqiqotlar diagnostik accuracy, patient outcome, cost, equity va cybersecurityni birgalikda baholashi kerak.

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