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Review Article

Comparative Effectiveness of Cryosurgery Versus Electrocautery in the Treatment of Cutaneous *Verruca Vulgaris*: A Systematic Review

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Abstract

Verruca vulgaris is an HPV infection requiring effective destructive management. This systematic review aims to compare the effectiveness of cryosurgery and electrocautery using recent randomized controlled trials (RCTs). A systematic search was conducted across five databases (PubMed, Semantic Scholar, Springer, Google Scholar, and Wiley) under PROSPERO ID CRD420261364850. Five RCTs met the inclusion criteria using the JBI Critical Appraisal Tool. From 1,857 records. The results show that electrocautery is effective for deep lesions (cure rate of 73-76%) compared with standard cryotherapy (cure rate of 44-58%). However, cryotherapy shows an excellent safety profile with lower pain and less scarring (6.7% vs 33.3%). Cryotherapy also induces a systemic immune response (distant response: 33.3%) and a lower recurrence rate (16.6% vs 23%).

Electrocautery is more effective for rapid local tissue destruction in deep lesions, whereas cryotherapy provides a safer therapeutic approach with additional immunological benefits that may reduce long-term recurrence. Both modalities remain effective options, and treatment selection should consider lesion characteristics, patient comfort, and recurrence risk.

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Introduction

Verruca vulgaris, or common warts, is a benign epidermal infection caused by several types of Human Papillomavirus (HPV) and affects approximately 10% of the global population.[1] Although this condition can develop at any age, warts are rarely observed in infancy and in early childhood under 4 years of age.[2] The prevalence of warts is estimated to increase to 20% among school-aged children, peaking between 12 and 16 years of age.[1] Clinically, these lesions present as hyperkeratotic papules that commonly appear on areas exposed to trauma or pressure, such as the hands and feet, and may cause a significant psychosocial impact due to their visibility.[3]

The epidemiological distribution of this condition shows significant variation based on ethnic and geographic background. Warts are reported to occur twice as frequently in White individuals compared to Black or Asian individuals.[1] In addition, there is a rare but benign variant known as focal epithelial hyperplasia or Heck's disease, which is associated with HPV types 13 and 32 and primarily affects the oral cavity. Heck's disease demonstrates a higher prevalence among certain Indigenous populations, such as Native American and Inuit groups.[4] These demographic and ethnic variations highlight the need

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for a more comprehensive clinical management approach tailored to patient population characteristics.[5]

The current treatment landscape for *verruca vulgaris* is highly diverse; however, cryosurgery and electrocautery remain the primary options in various healthcare settings due to their ability to rapidly destroy wart tissue and their relatively affordable cost.[2] Cryosurgery works by inducing necrosis through liquid nitrogen freezing, while electrocautery uses electrical energy to generate heat that causes tissue coagulation. Although both modalities are widely used, their effectiveness and cost-effectiveness compared to other treatment options remain under ongoing research and debate among dermatology practitioners.[6]

Comparative effectiveness studies indicate that electrocautery is superior for treating deep-rooted or plantar warts, with clearance rates of 76% compared to 44% for cryosurgery.[7] However, in terms of patient comfort and safety profile, cryosurgery is often preferred due to its lower risk of scarring and better cosmetic outcomes, particularly in sensitive areas.[8] These differences in outcomes are often influenced by application techniques and specific lesion characteristics, with electrocautery being more effective for thick, hyperkeratotic lesions, whereas cryosurgery is more suitable for superficial lesions.[9]

Currently, high-quality randomized controlled trials (RCTs) directly comparing the effectiveness of cryosurgery and electrocautery remain limited.[10] The inconsistency of data in the existing literature makes it difficult for clinicians to establish the optimal treatment standard for specific wart conditions.[11] This systematic review was designed to address this gap by critically evaluating data from recent RCTs regarding cure rates, safety profiles, and patient satisfaction. The findings of this review are expected to provide a clearer clinical framework for selecting the most appropriate therapy to improve patient quality of life.

Methods

This study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 guidelines.[12] The systematic literature review followed the PRISMA 2020 statement: Updated guidelines for reporting systematic reviews. The protocol was prospectively registered with the PROSPERO international database (CRD420261364850), reflecting a commitment to transparency and methodological rigor. The decision to perform a systematic review was based on its capacity to provide comprehensive insights into current clinical approaches and practices regarding the subject matter.

Search Strategy The literature search process was executed based on predefined criteria and conducted independently by multiple reviewers (SJP, PMPP, KKW, PAM). The search strategy utilized the PICO (Population, Intervention, Comparison, Outcome) framework, defined as follows: population (patients with cutaneous *verruca vulgaris*), intervention (cryosurgery or cryotherapy), comparison (electrocautery or electrosurgery), and outcomes (therapeutic efficacy, including clearance rates, healing time, recurrence, and safety profiles). A systematic search was performed across five electronic databases: PubMed, Semantic Scholar, Springer, Google Scholar, and Wiley Online Library. The strategy employed a combination of keywords and Medical Subject Headings (MeSH) terms using Boolean operators (AND, OR). The search string included: “Verruca Vulgaris” OR “Common Warts” OR “Viral Warts” OR “Non-genital Warts” AND “Cryosurgery” OR “Cryotherapy” OR “Intralesional Cryosurgery” OR “Cryoablation” AND “Electrocautery” OR “Electrosurgery” OR “Electrodesiccation” OR “Cauterization” AND “Comparative Effectiveness” OR “Clearance Rate” OR “Treatment Efficacy” OR “Safety.” Additionally, a manual search (hand-searching) of the reference lists of relevant articles was conducted to ensure that no pertinent studies were overlooked. The keywords used for this research based PICO **(Table 1)**.

Table 1 Keyword PICO.

PICO Element	*Keyword 1*	*Keyword 2*	*Keyword 3*	*Keyword 4*
P (Patient/Problem)	Cutaneous Verruca Vulgaris	Common Warts	Viral Warts	Non-genital Warts
I (Intervention)	Cryosurgery	Cryotherapy	Intralesional Cryosurgery	Cryoablation
C (Comparison)	Electrocautery	Electrosurgery	Electrodesiccation	Cauterization
O (Outcome)	Comparative Effectiveness	Clearance Rate	Treatment Efficacy	Safety Profile

Eligibility Criteria The inclusion criteria for this systematic review were: (1) studies involving patients diagnosed with cutaneous *verruca vulgaris*, excluding plantar, genital, mucosal, or other skin lesions; (2) studies directly comparing cryosurgery with electrocautery; (3) studies capable of evaluating the individual effects of each intervention without the confounding bias of combination therapies; (4) research utilizing a randomized controlled trial (RCT) design; (5) reporting of at least one clinical outcome, such as clearance rate, healing time, recurrence, or adverse effects; and (6) human-subject research. The exclusion criteria were: (1) case reports, case series, editorials, letters to the editor, conference abstracts, and narrative reviews; (2) animal or *in vitro* studies; (3) articles failing to report relevant clinical outcomes; and (4) articles that did not explicitly address the direct comparison between cryosurgery and electrocautery.

Selection Process Article selection was performed in multiple stages by independent reviewers (SJP, PMPP, KKW). The initial phase involved identifying articles through the specified databases, followed by the removal of duplicates. Subsequently, records were screened based on title and abstract to assess suitability against the eligibility criteria. Articles passing this stage underwent full-text assessment to confirm final eligibility. Discrepancies between reviewers were resolved through discussions until a consensus was reached, with an additional researcher (PAM) acting as an arbitrator if necessary. The selection process was supplemented by a manual search of references from included articles to ensure data completeness.

Data Extraction was conducted independently by two researchers (SJP, PMPP) using a standardized extraction form to minimize bias and errors. Extracted data included article title, author(s), year of publication, country of study, research design, sample size, participant characteristics, type of intervention, and clinical outcomes. Furthermore, data concerning therapeutic efficacy (clearance rates, healing time, recurrence) and safety profiles (pain, scarring, secondary infection, and other adverse effects) were collected. Discrepancies in extraction were resolved through consensus, involving a third researcher (KKW) as a mediator when required. The synthesized data were organized into a summary table to facilitate analysis.

Quality Assessment A critical appraisal of study quality was conducted prior to data analysis to ensure the validity of the included articles. This assessment was performed independently by two reviewers (KKW, PAM) using instruments tailored to the respective research designs. Evaluated domains included randomization methods, baseline comparability of treatment groups, completeness of follow-up, and objectivity of outcome measurements. Disagreements were resolved through consensus. Articles meeting the established methodological quality standards proceeded to the extraction and analysis phase. The results of the Quality Appraisal using the Joanna Briggs Institute (JBI) tool for RCT designs[13] are presented in **Table 2**.

Data Analysis

Data synthesis was performed narratively by two independent researchers by comparing findings from each RCT that met the inclusion criteria. This approach was selected due to the observed variations in research design, participant characteristics, and

Table 2 Critical Appraisal JBI.

Authors name [Ref.]	*Desain Penelitian*	*JBI*			
		Yes (%)	*No (%)*	*Unclear (%)*	*N/A (%)*
Singh & Neema [15]	Prospective RCT	76,9%	15,4%	7,7%	0%
Anwar et al.[7]	Randomized Trial	76,9%	15,4%	7,7%	0%
Jaiswal et al.[16]	Randomized Control Trial	69,2%	15,4%	15,4%	0%
Awad et al.[17]	Randomized Controlled Study	69,2%	15,4%	15,4%	0%
Attwa [18]	Randomized Controlled Study	69,2%	15,4%	15,4%	0%

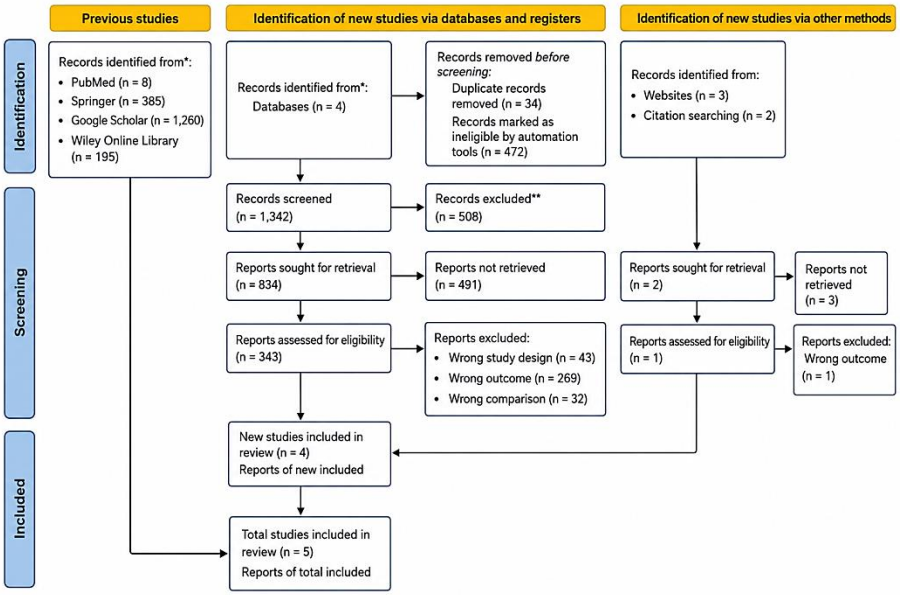

Figure 1 Article search flowchart.

interventional protocols across studies. Data were systematically categorized into three primary themes for evaluation: (1) clinical efficacy and clearance rates based on visual lesion clearance; (2) safety profiles and patient tolerance, encompassing pain levels, scarring risk, and pigmentary changes; and (3) systemic immune response and therapeutic stability through the evaluation of recurrence rates. A meta-analysis was not performed due to significant technical heterogeneity between studies; thus, results are presented as a structured narrative synthesis to determine the relative effectiveness of cryosurgery versus electrocautery.

Results

The study selection process was executed in successive stages and conducted independently by the review team (SJP, PMPP, and KKW). Initial database identification via PubMed (8), Springer (385), Google Scholar (1,260), and Wiley Online Library (195) yielded a total of 1,848 records. An additional four records were identified through other databases and five through alternative methods (including websites; 3 and citation searching; 2). Following the removal of 34 duplicates and the exclusion of 472 records by automation tools, 1,342 records remained for title and abstract screening. During this phase, 508 articles were excluded due to a lack of relevance, leaving 834 reports for full-text retrieval. However, 491 reports could not be retrieved, resulting in 343 articles being assessed for eligibility. Of these, 338 articles were excluded for specific reasons: ineligible study design (43), irrelevant outcomes (269), and interventions that did not meet the predefined PICO criteria (32). Furthermore, one additional record was excluded due to an unsuitable outcome (1). Any discrepancies during the selection process were resolved through consensus-building discussions, with a senior investigator (PAM) serving as an arbitrator when necessary. Consequently, five studies met all inclusion criteria. All included studies were randomized controlled trials (RCTs) directly comparing cryotherapy and electrocautery, which were subsequently advanced to the final qualitative synthesis. The detailed study selection workflow is illustrated in **Figure 1**.

Characteristic of the Study

The characteristics of the studies included in the analysis include the authors, study design, sample size, study location, wart type, and measured

outcomes. The total sample size across the five analyzed studies was 324 respondents, consisting of four studies with a randomized controlled trial (RCT) design[7,16-18] and one prospective randomized controlled trial (PRCT) (Singh & Neema, 2019). Based on geographic distribution, the studies were conducted in several countries, namely India,[15,16] Egypt,[16,17] and Pakistan.[7] The characteristics of the studies are presented in **Table 3**.

Synthesis

Table 4 presents a thematic analysis matrix mapping the findings from five randomized controlled trials:[7,15-18]

Theme 1: Clinical Efficacy and Cure Rate

The analysis of cure rates indicates ongoing debate regarding the most effective modality. Anwar[7] and Jaiswal[15] agree that electrocautery achieves significantly higher cure rates (73-76%) than standard cryotherapy (44-58%). This is likely because electrocautery can destroy tissue more deeply and precisely in thick lesions. However, Singh and Neema observed that both modalities resulted in statistically comparable outcomes (75% vs 73.3%).[15] This difference is most likely due to the cryotherapy technique; Singh applied three freeze thaw cycles, which are more aggressive than those used in other studies, showing that cryotherapy efficacy is highly dependent on the operator and protocol.

Theme 2: Safety Profile and Patient Tolerance

In terms of safety, cryotherapy consistently outperforms electrocautery. Regarding pain, Anwar[7] reported a very high incidence of post-procedural pain with electrocautery (72%), which is consistent with the findings of Singh & Neema (P=.003).[15] This is further compounded by a significant risk of scarring associated with electrocautery (33.3%) compared to cryotherapy (6.7%) according to Singh's study. From an aesthetic perspective, Jaiswal noted that although cryotherapy may cause temporary pigmentary changes, electrocautery carries a higher risk of permanent damage, including atrophic scarring, which is more cosmetically concerning.[16]

Theme 3: Systemic Immune Response and Outcome Stability

The unique advantage of cryotherapy lies in its ability to induce an immune response. Awad[17] provides strong evidence that intralesional cryotherapy not only clears treated warts but also induces healing in untreated warts (distant response) at a rate of 33.3%, which is associated with increased levels of cytokines IFN-γ and IL-12. This is supported by Attwa (2020), who states that cold-induced destruction in cryotherapy is more effective at exposing viral antigens to the immune system than thermal destruction in electrocautery. This also correlates with lower recurrence rates in the cryotherapy group (16.6%) than in the electrocautery group (21.9-23%), as reported by Singh and Awad.[15,17]

Discussion

Theme 1: Clinical Efficacy and Depth of Tissue Destruction

The effectiveness of wart therapy is significantly influenced by the physical characteristics of the lesion and the aggressiveness of the treatment protocol applied. Electrocautery is highly effective for solitary and deep warts, such as plantar warts, due to its precise thermal penetration. Technically, this method relies on the principle of instantaneous protein denaturation, which minimizes the risk of residual viral particles remaining at the base of the lesion, thereby offering a mechanical advantage for rapidly destroying thick keratinized masses. These findings are supported by clinical data showing that electrocautery achieves a complete clearance rate of 76%, significantly outperforming standard cryotherapy, which reaches only 44%. This advantage in thermal penetration is particularly beneficial for effectively destroying wart tissue while minimizing damage to the surrounding healthy tissue. In terms of time efficiency, electrocautery is

Table 3 Characteristic of Study.

Author [Ref.]	*Design*	*Sample*	*City & Country*	*Type of Wart*	*Measured Outcome*
Singh & Neema [15]	RCT	75	New Delhi, India	Common & Plane	Efficacy (clearance), recurrence, patient satisfaction, dermatoglyphics, scarring, and pigmentation
Anwar et al.[7]	PRCT	108	Kolkata, India	Plantar	Clearance rate, pain, wound healing, scarring, dyspigmentation, and recurrence
Jaiswal et al.[16]	RCT	31	Assiut, Mesir	Extragenital Common	Target wart efficacy, distant response, cytokine levels (IL-12, IFN-γ), and adverse effects
Awad et al.[17]	RCT	50	Sahiwal, Pakistan	Plantar, Palmar, others	Efficacy by wart type, pain, erythema, and scarring
Attwa [18]	RCT	60	Zagazig, Mesir	Multiple Common	Clearance rate, safety, patient satisfaction, and relapse rate

Table 4 Thematic Analysis Matrix Comparing Cryosurgery versus Electrocautery.

Main Thema	*Sub-Thema*	*Author-Years*	*Result Quotes*
Theme 1: Clinical Efficacy and Cure Rate	Comparison of efficacy based on technique and wart location	Anwar *et al*. [7]	"Electrocautery was found to be effective therapy… complete clearance noticed in 76% patients as compared to cryotherapy in 44%."
		Jaiswal *et al*. [16]	"Complete cure in Group B (Electrodesiccation) was 17 (73%) and in Group C (Cryosurgery) was 14 (58%) (P ≤ 0.001)."
		Singh & Neema [15]	"The overall clearance rate was 75% in electrosurgery versus 73.3% in cryotherapy patients (P = 0.827)."
Theme 2: Safety and Patient Tolerability	Pain and procedural comfort	Anwar *et al*. [7]	"Common side effects of electrocautery observed were post procedural pain in 72%… cryotherapy is quick and painless."
		Singh & Neema [15]	"The pain was significantly higher in case of electrosurgery compared with cryotherapy (P = 0.003)."
		Awad *et al*. [17]	"Intralesional cryosurgery was well tolerated; infection and ulceration occurred only with electrosurgery."
	Tissue damage and aesthetic impact [scarring & pigmentation]	Singh & Neema [15]	"Scarring incidence was significantly higher (33.3%) for electrosurgery compared with 6.7% for cryotherapy (P = 0.0008)."
		Jaiswal *et al*. [16]	"At 12th week, 34% patients had scarring… 46% patients in cryosurgery group showed pigmentary changes."
Theme 3: Systemic Immune Response and Outcome Stability	Long-term recurrence rate	Awad *et al*. [17]	"Recurrence of the treated warts was detected in 23% in the electrosurgery group, whereas no recurrence was found after IL cryosurgery."
		Singh & Neema [15]	"Recurrence at 24 weeks was observed in 21.9% of the electrosurgery patients which was slightly higher than cryotherapy (16.6%)."
	Immune response activation against HPV	Awad *et al*. [17]	"Resolution of distant untreated warts was seen in 33.3% after IL cryosurgery… increase in IFN-γ and IL-12 levels."

also superior, as it often requires only one or a few treatment sessions compared to conservative therapies that may take several weeks.[19,20]

However, counteranalysis indicates that the lower efficacy of cryotherapy in some studies is often due to less aggressive protocols rather than an inherent limitation of the modality itself. Cryotherapy has been shown to achieve clearance rates comparable to electrocautery (73.3% vs 75%) when applied using specific protocols such as three freeze-thaw cycles. The use of multiple cycles is crucial, as it significantly increases the depth and extent of tissue necrosis, reaching the basal layer of the epidermis.[21] The effectiveness of this technique also varies depending on thermal dynamics, including freezing duration, spray distance, and nozzle diameter used during the procedure.[22,23] Therefore, the standardization of aggressive protocols is essential for cryotherapy to achieve optimal outcomes and match the destructive capability of electrocautery.[23]

Theme 2: Safety Profile, Tolerability, and Aesthetic Impact

The safety aspect in wart management shows a trade-off between the speed of clearance and post-procedural morbidity. Electrocautery, although highly effective for deep-rooted lesions, is associated with significantly higher post-procedural pain and a greater risk of permanent scarring due to serious thermal damage. Data indicate that the incidence of permanent scarring can reach 33.3% with electrosurgery, compared with 6.7% with cryotherapy. This dermal tissue damage may negatively affect patients' quality of life, particularly in terms of functional comfort in plantar areas and long-term cosmetic outcomes.

In contrast, cryotherapy consistently offers a superior safety profile with lower and more tolerable pain levels, thereby improving patient adherence to the treatment regimen. From an aesthetic perspective, although cryotherapy may cause temporary hypopigmentation due to melanocyte sensitivity to cold temperatures, this effect is generally reversible and does not damage the structural framework of the skin tissue.[24] This advantage is particularly crucial in the pediatric population, where cryotherapy is preferred for its rapid, non-invasive procedure and its ability to provide better cosmetic outcomes with minimal risk of scarring.[25] The use of a structured protocol remains necessary to minimize these aesthetic concerns while maintaining treatment efficiency.[23]

Theme 3: Systemic Immune Response and Stability of Therapeutic Outcomes

The fundamental difference between cryotherapy and electrocautery lies in the biological response triggered after the procedure. Cryotherapy, particularly the intralesional technique, not only functions as a local destructive agent but also serves as a trigger for an immune response that resembles an in situ vaccine. The process of cell lysis due to cold exposure releases HPV viral antigens into the circulation in an intact state, allowing optimal recognition by the immune system and inducing a systemic immunological response known as cryoimmunization.[26] This is evidenced by the phenomenon of distant response (resolution of untreated warts) at 33.3%, accompanied by increased levels of pro-inflammatory cytokines such as IFN-γ and IL-12. In contrast, electrocautery works through thermal destruction, denaturing viral proteins and their antigens, thereby providing no additional immune stimulation to the body.[27]

The clinical implications of this biological mechanism indicate that cryotherapy has an advantage in long-term outcome stability. This systemic immune activation explains why recurrence rates in the cryotherapy group are consistently lower (16.6%) than in the electrocautery group (21.9 to 23%) during long-term follow-up. While electrocautery typically lacks additional immune stimulation, modifications through combination therapy may enhance its efficacy in preventing recurrence. A recent report in the literature demonstrated that combining electrosurgery with 90% trichloroacetic acid (TCA) successfully

managed recurrent *verruca vulgaris* with no new lesions observed during a five-month follow-up.[28] Although electrocautery is effective for the immediate destruction of keratinized masses, cryotherapy's ability to induce immunological memory makes it a more advantageous modality for preventing relapse, particularly in multiple warts. However, it should be noted that this immunogenic effectiveness may vary in immunocompromised patients with a lower baseline immune response.[26]

Conclusion

This systematic review concludes that cryosurgery and electrocautery are effective physical destructive modalities in the treatment of *verruca vulgaris*; however, the selection of therapy should be tailored to the patient's clinical profile. Electrocautery tends to provide higher and faster clearance efficacy in deep solitary warts, such as plantar types, through a precise thermal penetration mechanism. On the other hand, cryotherapy offers a superior safety profile with lower post-procedural pain and a minimal risk of scarring, making it more preferable for pediatric populations and lesions in cosmetically sensitive areas. In addition, cryotherapy has a unique advantage in inducing a systemic immune response (distant response), which plays an important role in reducing long-term recurrence rates compared to electrocautery.

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Author's contribution

SJP: Substantial contribution to conceptualization, methodology, formal analysis, Data Extraction, Writing Original Draft.

PMPP: Data extraction, quality assessment (JBI Critical Appraisal), writing- review & editing manuscript.

KKW: Supervision, validation, final approval of the manuscript.

PAM: Literature searching, screening, and study identification, validation.

Every author has given final approval of the manuscript version to be published and agreed to be accountable for all aspects of the work.

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