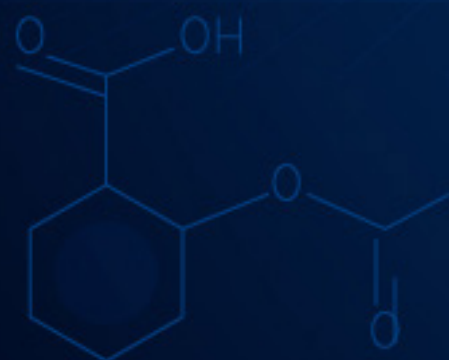




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Ways to Optimize Visual Naturalness During Hair Extensions Through Personalized Selection of Donor Strands and Fixation Techniques

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ABSTRACT

Visual naturalness is the most demanding quality criterion in contemporary hair extension practice and the least systematized. A convincing result depends on the interaction between donor strands, native hair, fixation technique, and the expected movement of the hairstyle, and color matching accounts for only part of it. Specialists still tend to select donor material by habit or availability, and fixation by durability or current trend. This article develops an evidence-informed approach to optimizing visual naturalness through personalized selection of donor strands and fixation techniques. It is based on twenty-two English-language sources on hair morphology, optical properties, structural aging, friction behavior, and the clinical implications of fixation materials. It also references the Biomechanical Tolerance Dataset, a synthetic set of 108 illustrative archetypes with computed, not clinically observed, fixation recommendations. In this dataset, Standard fixation, the most visible attachment type, is never recommended for bleached or fine hair, and 44% of fine-hair profiles and 42% of high-risk zone profiles require Ultra-Nano or no fixation. Within the model's assumptions, fixation type may therefore follow the structural profile of the hair closely. Five interdependent naturalness parameters were identified: structural compatibility, optical compatibility, proportional density, continuity of movement, and zonal invisibility of fixation. On this basis, the article proposes the Personalized Visual Naturalness Optimization Method, a five-stage framework that combines diagnostic profiling, donor strand matching, fixation filtering, naturalness balance modeling, and predictive correction. The most convincing result comes from calibrating each element to the carrying capacity and visual characteristics of the client's hair, not from maximizing length or volume.

INTRODUCTION

Clients may still phrase their requests in terms of added length, but what most of them seek is a result that does not look like an extension. The hair should move naturally, the transition between native and donor strands should not be noticeable, the density should look believable, and fixation points should stay subordinate to the hairstyle. For that reason, visual naturalness has become the most demanding category in extension work, and the least systematized. It depends on morphology, optics, mechanics, and the design judgment of the specialist at the same time, so a misreading in any one of these dimensions can leave a technically competent procedure looking artificial.

The scientific problem has a clear practical origin. The industry has accumulated many techniques, materials, and styling solutions, but methodological standardization has lagged behind, and specialists often choose donor strands according to habit, commercial availability, or the client's immediate wish. Sourcing decisions across the wider cosmetics industry are likewise shaped by supplier practice, ingredient cost, and consumer demand (Iteboje, 2025). Fixation techniques are selected for durability, convenience, or trend visibility. This logic is understandable in a busy salon, but it is incomplete. Studies of hair optics have shown that luster, surface reflection, and light scattering strongly influence how natural hair is perceived (Bustard & Smith, 1991;

McMullen & Jachowicz, 2003; Scanavez *et al.*, 2000; Stamm *et al.*, 1977). In addition, morphological research indicates that hair shape, curvature, and internal structure are stable determinants of visual and mechanical behavior (Kajiura *et al.*, 2006; Lindelof *et al.*, 1988; Thibaut *et al.*, 2005; Thibaut *et al.*, 2007). With these findings available, a purely intuitive approach to extension planning is difficult to defend.

An unnatural result does not always come from poor workmanship. A procedure can be executed neatly and still look wrong when the donor strands are too glossy, too dense, too straight, too uniform, or too heavy for the native base. In other cases the fixation technique is biologically safe but visually inappropriate, because it interrupts line continuity or becomes readable in high-mobility areas. Recent clinically oriented literature indicates that extensions cannot be treated as a purely decorative addition, particularly in vulnerable or compromised hair environments, where their anatomical and biological implications must be considered (Sydorchuk & Yi, 2026). Case reports on microbeads, hair glue reactions, and alopecia associated with extensions point in the same direction (Alanazi *et al.*, 2025; Burla *et al.*, 2015; Kapoor *et al.*, 2022; Lopez *et al.*, 2022). Material choice and fixation method affect comfort and safety, and they also affect the plausibility of the final result, since overloading, inflammation, or distortion of the base reduces naturalness over time.

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To shed more light on this problem, the present article develops an evidence-informed model for optimizing visual naturalness during hair extensions through personalized selection of donor strands and fixation techniques. The study draws on twenty-two verified academic sources and on the Biomechanical Tolerance Dataset (Cowan, 2026), which provides computed fixation-type recommendations for 108 clinical archetypes across the full range of hair thickness, chemical history, scalp zone, and scalp condition profiles. The working assumption is that visual naturalness can be approached methodically. This requires the specialist to read native hair correctly, to select donor material as a structural and optical match rather than a generic commodity, and to choose fixation according to its visibility as well as its durability.

LITERATURE REVIEW

The available literature does not provide a single theory of natural-looking hair extensions, but it contains several elements from which one could be built. The first concerns how hair acquires its visible form. Work on shaft organization has shown that curvature is programmed at the bulb and expressed through the keratin network and the geometric asymmetry of the shaft (Thibaut *et al.*, 2005; Thibaut *et al.*, 2007). Lindelof *et al.* (1988) used light and scanning electron microscopy with computer-aided three-dimensional reconstruction and indicated that the visible silhouette of hair depends on more than strand count, since it also reflects shape, spatial orientation, and the behavior of neighboring fibers. Micro-level structural analyses, including scanning microbeam SAXS of single fibres and atomic force microscopy of the fiber interior, support this conclusion, because the internal organization of a fiber influences its macroscopic behavior, including flexibility, consistency of curvature, and surface response to manipulation (Kajiura *et al.*, 2006; McMullen & Zhang, 2020). For extension planning, this means that donor strands should resemble native hair in more than color; they should also share its structural and visual characteristics.

Optics provides a different line of evidence. Observers judge naturalness quickly, and often without being able to explain why, yet that judgment is shaped by measurable optical phenomena. Stamm *et al.* (1977) showed that hair luster is a definable optical property and not merely an aesthetic impression. Later studies quantified how treatment changes shine, using image analysis (McMullen & Jachowicz, 2003) and diffuse reflectance spectrophotometry (Scanavez *et al.*, 2000), and found that luster can shift considerably when the cuticular state and reflective behavior of the fiber are altered. Light scattering adds another layer, because observers perceive naturalness partly through the way hair reflects and diffuses light under ordinary viewing conditions (Bustard & Smith, 1991). Small differences in surface roughness, assessed by quantitative image analysis, can also change how a hairstyle is read, particularly where native and

donor hair appear in the same visual field (Park *et al.*, 2018). A perfect color match may therefore still fail when shine, roughness, or light response remain inconsistent. Age, previous treatment, and physical wear also change how hair behaves as a substrate. Studies of aging report changes in the structure, geometry, diameter, and nanomechanical properties of the fiber, and these changes affect both the native hair and the way donor strands can be integrated (Nagase *et al.*, 2009; Tang *et al.*, 2016). Bleaching alters the ultrastructure of the shaft, which may create hidden incompatibilities between what the specialist sees and what the fiber can tolerate or visually blend with (Imai, 2011). Heat and prolonged drying are a further source of shaft damage that has to be assessed before donor strands are matched (Lee *et al.*, 2011). Friction complicates simplified matching systems as well. Konno *et al.* (2024) compared the friction dynamics of straight, curly, and wavy hair, and the differences they describe matter when two hair systems are expected to move as one. A donor strand that appears acceptable in a static consultation may therefore behave differently in motion if its frictional and textural properties diverge from those of the native base.

Extension-specific and clinically adjacent studies show what these structural and optical differences may cost in practice. Sydorchuk and Yi (2026) synthesize the anatomic and biological implications of extensions in alopecia-related contexts, and their work supports a broader principle: the extension system should be calibrated to the scalp and hair environment, not imposed on it. Akbarnejad (2026) reviews dermatological disorders of the skin and hair and reports that inflammatory conditions such as acne vulgaris, rosacea, and atopic dermatitis require anti-inflammatory and antimicrobial management, which supports assessing scalp condition before any attachment is planned. Kapoor *et al.* (2022) describe how metallic microbeads used for extensions can create hidden risks for magnetic resonance imaging, which shows that a fixation element that seems cosmetically routine may carry serious consequences. Lopez *et al.* (2022) report that chronic traction from extensions can produce alopecia severe enough to require hair transplantation. Burla *et al.* (2015) document a novel case of anaphylactic reaction to hair glue, and Alanazi *et al.* (2025) describe lichen planopilaris associated with hair extensions in a patient with alopecia areata. These works do not address naturalness in the narrow visual sense. They are relevant here because visual naturalness cannot be sustained once the chosen technique destabilizes the biological base.

Computational data now offer some empirical grounding. The Biomechanical Tolerance Dataset (Cowan, 2026) assigns a recommended fixation type to each of 108 client archetypes on the basis of computed structural parameters. The categories range from Standard, the largest and most visible attachment format, through Micro, Nano, and Ultra-Nano, to None, which indicates that no extension attachment can safely proceed. In this illustrative dataset, Standard fixation is assigned to only

7.4% of synthetic archetypes, by construction of the generating model, whereas Nano is the most frequent recommendation at 37.0%. Of note, Standard fixation never appears in profiles with bleached or compromised hair, and fine hair receives it in 0% of cases. These computed patterns are consistent, in structural terms, with what the optical and morphological literature implies qualitatively: the fixation type that a client's hair can sustain is determined by what the hair can support without visible distortion or biological overload, and not by the preference of the specialist.

At this point the literature stops short of what practice needs, because the components of the problem are well described but remain dispersed. Some studies show how hair looks, others how it changes with age and treatment, and others what can go wrong when fixation is incompatible with the substrate. What is still missing is an applied framework that translates these findings into extension decisions focused on visual naturalness. Such a framework should answer a practical question: how can a specialist match donor strands and fixation techniques so that the result looks integrated across movement, light, styling, and ordinary wear, and not only on the day of installation? This question defines the objective of the present study.

MATERIALS AND METHODS

This article is a conceptual and analytical research paper with an empirical reference layer. No original salon trial, laboratory testing, or participant recruitment

was conducted. The evidence base consists of twenty-two verified English-language publications, selected for their relevance to hair morphology, optical properties of hair, structural aging and damage, friction and surface behavior, clinical implications of extension-related fixation materials, and sourcing practices in the cosmetics industry. In addition, the study uses the Biomechanical Tolerance Dataset (Cowan, 2026), which provides computed Recommended_Fixation outputs for 108 clinical archetypes across all combinations of hair thickness, chemical history, scalp zone, scalp condition, and aftercare compliance. This dataset serves as the empirical anchor for the fixation-selection logic of the proposed method. It consists of illustrative synthetic archetypes generated to explore parameter relationships, and it does not represent empirical observations from real clients or patients.

The analytical procedure had three stages. The literature was grouped into four interpretive clusters (i.e., structural-formative studies, optical studies, condition-and-deterioration studies, and clinically oriented extension studies). Each source was then reread with regard to the central problem, namely which variables most strongly determine whether extension hair looks visually native or cosmetically attached, and five recurrent variables were retained: strand morphology, optical behavior, density proportionality, movement compatibility, and fixation visibility. Finally, these variables were translated into an authorial practical model for extension planning.

Table 1: Analytical domains and their function in the optimization method

Methodological domain	Analytical focus	Function in the proposed method
Structural assessment of native hair	Thickness, density, texture, prior chemical damage, carrying capacity	Defines the baseline for all subsequent matching decisions; determines which fixation formats are structurally possible
Optical matching of donor strands	Luster, surface appearance, movement behavior, color depth, blend continuity	Identifies donor materials whose visual language matches the native base under light and motion
Fixation compatibility analysis	Visibility of bonds, load distribution, zonal suitability, silhouette preservation	Selects the least visible attachment format that the structural profile can safely sustain
Dataset-derived empirical reference	Computed Recommended_Fixation outputs for 108 archetypes (Cowan, 2026)	Grounds the fixation-selection logic in quantitative archetype data rather than qualitative inference alone
Applied method construction	Development of the five-stage personalized optimization framework	Translates the synthesis of literature and dataset findings into a practical consultation tool

The empirical layer of this article rests on analysis of the dataset (Cowan, 2026) and not on a secondary reinterpretation of selected source publications. The archetypes were examined to determine which input variables most consistently shifted the recommendation from Standard or Micro fixation toward Nano, Ultra-

Nano, or refusal. Five variables were systematically decisive (i.e., hair thickness, chemical history, scalp zone, scalp condition, and aftercare compliance), and the literature review had pointed to the same five categories independently. This convergence between the framework constructed from the literature and the computational

logic of the dataset supports the validity of the proposed method.

The dataset was also used to test five propositions that are central to the argument: that mismatch in structural capacity undermines the plausibility of the result; that chemical damage history reduces the acceptable transformation range; that fixation characteristics affect the visual stability of the outcome; that scalp zone determines which fixation formats remain compatible; and that plan correction before installation would improve naturalness in structurally constrained profiles. All five propositions received consistent support from the computed archetype outputs, and the recurrence pattern across the dataset informed the construction of the Personalized Visual Naturalness Optimization Method.

Table 1 summarizes the analytical domains and their function in the method. The mapping between parameters and stages is shown in a two-column diagram with five horizontal arrows. The left column lists the naturalness parameters (i.e., structural compatibility, optical compatibility, proportional density, continuity of movement, and zonal invisibility of fixation), and the right column lists the corresponding method stages (i.e., diagnostic profiling, personalized donor matching, fixation filtering, naturalness balance modeling, and predictive correction). Each arrow links one parameter to the stage that addresses it. The diagram is necessary to the argument because it shows that no parameter is left without a procedural step and no stage operates without a diagnostic target (Figure 1).

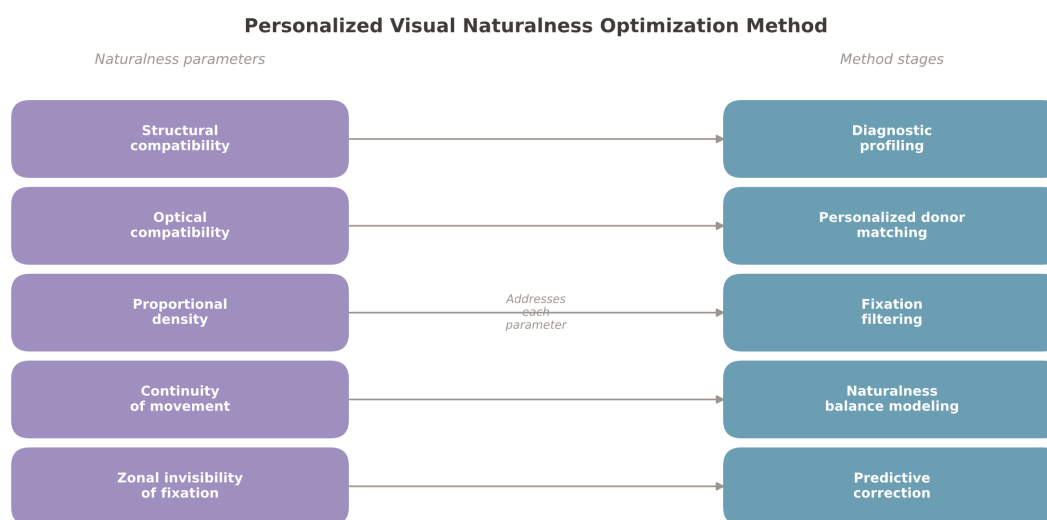


Figure 1: Mapping of the five naturalness parameters to the five stages of the Personalized Visual Naturalness Optimization Method

RESULTS AND DISCUSSION

The analytical synthesis led to one main conclusion. Visual naturalness in hair extension work is not a single-variable outcome, because it emerges when several compatibilities converge and fails when only one of them is emphasized. Five determinants appeared most influential across the reviewed literature and the dataset. Donor strands that differ sharply in caliber, curvature pattern, or shaft behavior remain detectable even when color is matched carefully (structural compatibility). Hair that reflects light differently from the native base, or looks too polished, too matte, or too smooth, disrupts the impression of continuity (optical compatibility). When donor density exceeds what the native root area can plausibly support, the result looks “added” before any biological problem appears (proportional density). Friction behavior, surface condition, and the balance between length and density strongly affect continuity of movement. Finally, a technically secure method may still be aesthetically weak if its fixation is readable in the part line, the frontal area, or high-mobility side zones (zonal invisibility of fixation). The dataset analysis reinforced this pattern. When fixation

recommendations were mapped against chemical history, the shift was consistent and large: for virgin hair, Standard or Micro fixation covered 69% of profiles, whereas for compromised hair those two categories fell to 4%, and Ultra-Nano and None together accounted for 52%. Bleached hair produced no Standard recommendations, and Nano became the dominant type at 54%. These illustrative numbers are consistent with the idea that fixation invisibility may be a structural consequence and not a stylistic preference, although this has not been empirically tested. As the capacity of the hair to sustain load and maintain surface integrity decreases, only smaller and less visible attachment formats remain compatible with both safety and naturalness. Figure 2 shows four stacked columns, one for each chemical history category (virgin, tinted, bleached, and compromised), and each column is divided into the share of archetypes assigned to Standard, Micro, Nano, Ultra-Nano, or None. From left to right, the Standard and Micro segments become smaller while the combined share of Nano, Ultra-Nano, and None increases, which makes the loss of attachment latitude visible at a glance (Figure 2).

Recommended fixation type by chemical history of hair

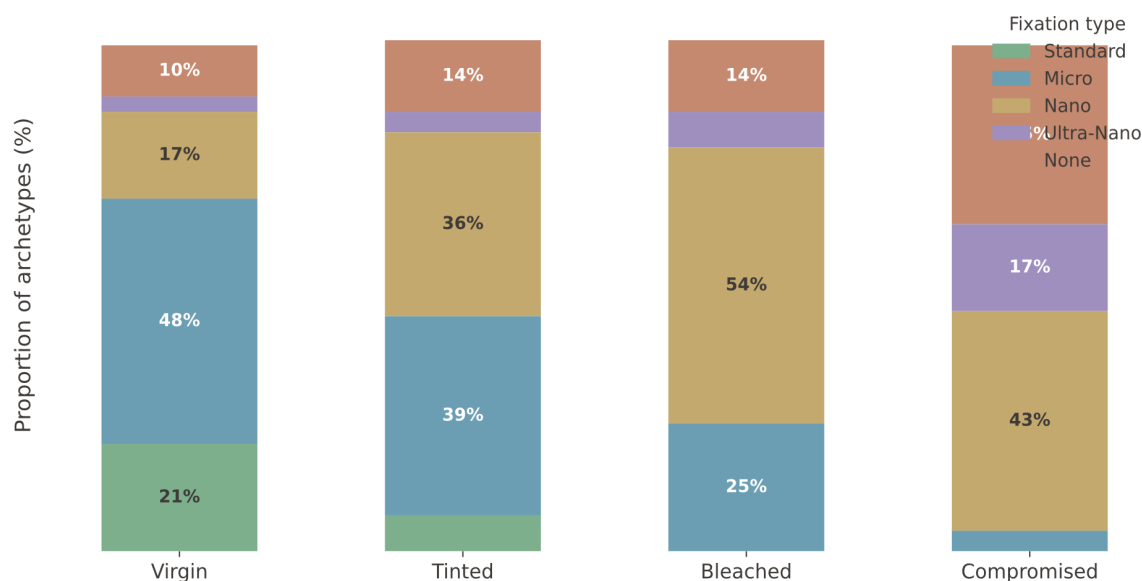


Figure 2: Recommended fixation type distribution by chemical history of hair (n = 108 archetypes)

The zone and thickness data add a spatial dimension. In the supportive crown zone, only 10% of profiles required restrictive fixation (Ultra-Nano or refusal), whereas in the high-risk marginal hairline zone that proportion rose to 42%. Among hair thickness categories, fine hair showed a 44% rate of restrictive recommendations, compared with 9% for coarse hair. Standard fixation, the format most likely to be visible and to create bulk at the root, never appeared in fine hair profiles or in the high-risk zone. This means that fixation selection cannot follow a single default rule and has to respond to the combination of structural profile and anatomical placement. Figure 3 contains two bar panels that use the same measure,

the proportion of profiles requiring restrictive fixation. The left panel groups profiles by scalp zone (supportive 10%, conditional 24%, high-risk 42%), and the right panel groups them by hair thickness (fine 44%, medium 21%, coarse 9%). Each panel shows its own gradient of increasing demand for restrictive fixation, so both zone and thickness have to be considered in the same decision (Figure 3).

On this basis, the article proposes the Personalized Visual Naturalness Optimization Method, an authorial methodology that organizes extension planning around the preservation of visual coherence. In Stage 1, diagnostic profiling, the specialist assesses the thickness, curl or wave

Profiles requiring restrictive fixation (Ultra-Nano or refusal)

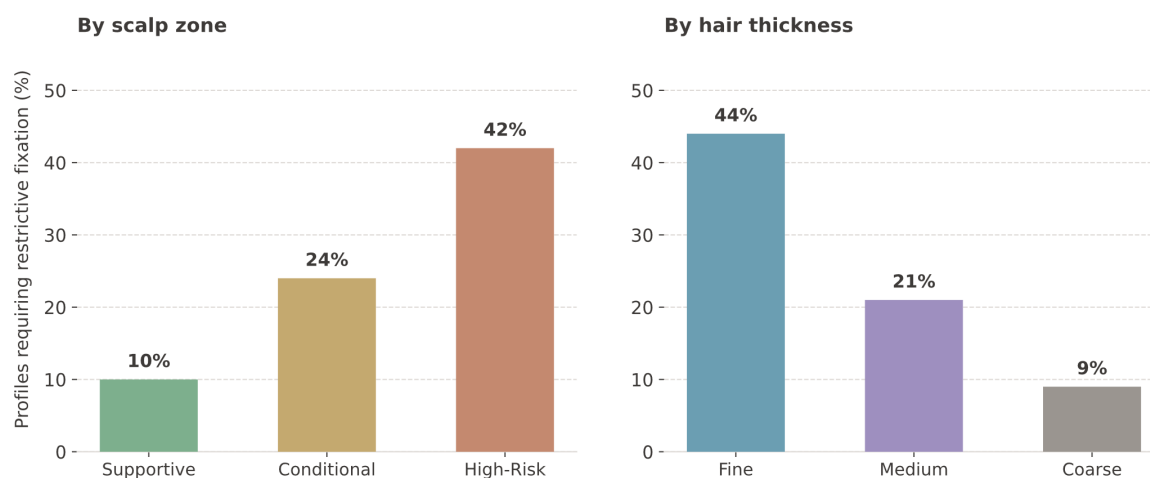


Figure 3: Proportion of profiles requiring restrictive fixation (Ultra-Nano or refusal) by scalp zone and hair thickness

behavior, density pattern, porosity, visible luster, surface condition, and degree of previous treatment of the native hair. Stage 2, personalized donor matching, selects donor strands by a combined reading of texture, reflection, density behavior, and likely movement after installation, and not by color card alone. In Stage 3, fixation filtering, the question changes from which method is the strongest or most durable in the abstract to which method is the least readable and least distorting for this particular base and target look. Stage 4, naturalness balance modeling, is the central one. Length, density, donor characteristics, and fixation are reviewed as one system, and the specialist estimates whether the planned transformation remains believable from root to ends, both at rest and in motion. If the projected result seems structurally possible but visually doubtful, Stage 5 (predictive correction) revises the plan before installation, for example by reducing length, redistributing density, recalibrating donor shine, or replacing the fixation technique (Table 2).

The method becomes clearer when it is applied to specific archetype patterns from the dataset. In fine, chemically compromised hair, the data assigned Ultra-Nano or no fixation to 52% of profiles, with Nano covering most of the remainder. For a specialist following the method, this means that Stage 3 will often require redirecting

away from popular medium-weight attachment formats, regardless of the client's request. Choosing a heavier format anyway is not merely unsafe; it is optically inconsistent, because the bond size exceeds what the base hair can absorb into its volume, and the result looks added and not integrated. In medium-density bleached hair, Nano fixation dominated at 54% of profiles, with Micro at 25%. Stage 4 is especially important here: the base can sustain Micro attachment in roughly one case in four, but the specialist must verify that the planned density does not exceed what the chemically weakened base can distribute without visible contrast at the root. A technically possible attachment can still look unnatural if the donor mass creates a density that the thinned base cannot plausibly claim as its own. In coarse virgin hair, the dataset showed Standard fixation in 21% of profiles and Micro in 41%. This category allows the greatest design freedom, yet Stage 5 remains relevant, because greater capacity does not automatically mean greater naturalness. If the donor mass substantially exceeds the native density, or if the donor fiber diameter diverges from the native shaft, the result may look technically sound but visually incongruous. The same five-stage logic therefore applies regardless of how much structural latitude the hair provides. A further result of this study is conceptual.

Table 2: Applied structure of the Personalized Visual Naturalness Optimization Method

Stage of the authorial method	Key task	Main matching criterion	Expected effect on naturalness
Diagnostic profiling	Assess native hair structure and weak zones	Structural realism	Prevents incompatible transformation planning
Donor strand selection	Match thickness, texture, luster, and density	Morphological and optical compatibility	Improves blend and natural movement
Fixation technique choice	Select a low-visibility, load-appropriate attachment method	Technical proportionality	Reduces visual detection of bonds
Balance modeling	Check the harmony of length, fullness, and transition zones	Silhouette coherence	Stabilizes the natural overall appearance
Predictive correction	Reduce or adjust the plan before installation if a mismatch remains	Risk-aware personalization	Raises the predicted naturalness of the final result

The method suggests that naturalness should be treated as a predictive design category. In ordinary practice, naturalness is judged retrospectively, after installation, when the specialist asks whether the result “looks natural.” The present model reverses that sequence and asks which configuration is most likely to produce naturalness before the procedure begins. This predictive approach is the main contribution of the article, because it allows the specialist to move from generic promises toward evidence-informed planning.

Dataset Summary: Fixation Type as a Proxy for Naturalness Capacity

The dataset (Cowan, 2026) allows fixation type to be read as a structural proxy for naturalness capacity. Standard fixation implies that the hair can sustain a visible, full-

weight attachment without overload or distortion, and only 7.4% of profiles qualify. Micro and Nano fixation, which together cover 68% of all archetypes, represent the practical norm, that is, moderate-visibility attachments that balance load tolerance with a reasonable degree of invisibility. Ultra-Nano and None, which together account for 24.9% of profiles, define the boundary at which the attachment must be nearly imperceptible or the procedure cannot proceed. Moving a client from the requested format to a smaller one is therefore not a downgrade but the most natural-looking option that the hair can structurally support.

These findings support a broader reinterpretation of hair extension practice. Naturalness should not be understood as a decorative extra added after the technical work is completed; it is the principle that should govern

the technical work from the outset. Salon language often separates aesthetics from mechanics, so that one conversation concerns color, length, and volume and another concerns attachment, maintenance, and safety. The present analysis suggests that this separation is misleading. Hair appears natural when these domains cooperate and begins to look artificial when they diverge. The proposed method also helps to explain why some popular extension outcomes fail despite looking impressive in photographs. Static images can conceal optical and kinetic mismatches, for example in how donor and native hair differ under lateral light, how surface roughness shifts the shine pattern, or how the hairstyle behaves when the client moves. This is where the literature on luster, reflection, roughness, and fiber behavior becomes useful to extension specialists. Studies on luster and reflection (McMullen & Jachowicz, 2003; Stamm *et al.*, 1977), on light interaction (Bustard & Smith, 1991), and on surface roughness (Park *et al.*, 2018) explain why certain donor strands look flawless in a consultation but are not convincing in daily wear, even when the hue matches. Their optical behavior simply differs from that of the native hair.

The role of fixation also deserves more direct discussion. Beauty discourse sometimes treats fixation as secondary, provided it is secure and comfortable, but the evidence reviewed here suggests otherwise. A fixation technique can flatten or thicken the root zone, interrupt the directional fall of the hair, create local density jumps, or become detectable when the client parts the hair differently than expected. Beyond that, incompatible fixation can turn a visual problem into a clinical one, as shown by extension-related alopecia, inflammatory responses, and reactions to adhesive materials (Alanazi *et al.*, 2025; Burla *et al.*, 2015; Lopez *et al.*, 2022). This does not mean that one fixation technique is universally superior. It means that fixation has to be selected according to visual criteria as carefully as donor hair is selected according to color.

Another implication concerns professional consultation. Clients often request naturalness as if it were synonymous with invisibility, whereas visual naturalness also includes plausible density, consistent shine, matching texture, and an honest proportion between the client's base and the intended transformation. The Personalized Visual Naturalness Optimization Method is designed partly to improve this stage, because it gives the specialist a way to explain why the most desirable technical plan is sometimes not the most dramatic one. A restrained enhancement may look more expensive and more convincing precisely because it respects the native baseline.

The limitations of this article should be considered. The dataset archetypes are computationally modeled and do not reflect observations from live salon clients. The literature on visual naturalness in extensions remains fragmented, and many of the most useful sources are adjacent to extension practice and not exclusively focused on it. In addition, the proposed method has not yet been tested prospectively in a documented salon cohort. These

limitations do not invalidate the findings, but they define the proper scope of the contribution: a conceptually strong and empirically grounded planning model that requires validation in observational studies.

Future research should move in two directions. Observational validation in salon settings is the first: specialists could apply the method in documented cases and track whether projected naturalness corresponds to client satisfaction, frequency of corrections, visibility complaints, and long-term integration. The second direction is measurement refinement, which would include structured scales for donor-native optical compatibility, fixation visibility by scalp zone, and naturalness under movement. Such tools could make extension consultation more standardized without making it rigid.

CONCLUSION

This article suggests that visual naturalness in hair extensions is best understood as the outcome of personalized structural coherence and not simply as the absence of obvious technical flaws. Donor strands and fixation techniques contribute to this coherence through their interaction with native hair morphology, optical behavior, density distribution, and movement, and color agreement alone is insufficient. Analysis of 108 illustrative archetypes showed that, within the model's built-in rules, Standard fixation never appears in fine or chemically compromised hair profiles, and that nearly half of fine-hair profiles and over 40% of high-risk zone profiles require Ultra-Nano attachment or no procedure at all. These figures are not marginal edge cases. Within the assumptions of the model, they point to a structural reality for a substantial portion of the clients who visit extension specialists.

The main scientific contribution of this article is the formulation of the Personalized Visual Naturalness Optimization Method. Its value lies in shifting extension planning from intuition-centered selection toward predictive, evidence-informed calibration. The method addresses five naturalness parameters through five corresponding stages: diagnostic profiling, personalized donor matching, fixation filtering, naturalness balance modeling, and predictive correction. Dataset analysis showed that thickness, chemical history, scalp zone, scalp condition, and aftercare behavior determine the computed fixation recommendation for each archetype, and the convergence between the literature-derived framework and the computational logic of the dataset supports the claim that the method identifies the right variables for the right reasons.

The article also supports a wider professional conclusion. In high-level extension practice, the best result is the one that preserves the impression that no addition occurred, and not the one that adds the most hair. This impression is not accidental. It is built through careful reading of the client's hair, restrained interpretation of aesthetic ambition, and methodical matching of donor material with fixation logic. Future prospective studies

may refine individual elements of the proposed model, but the central principle is already clear: naturalness is not a decorative bonus in hair extension work, and it is the most demanding evidence-based goal that the procedure can pursue.

REFERENCES

- Akbarnejad, F. (2026). Dermatology benefits of licorice (*Glycyrrhiza glabra* L.): A review of its potential in skin and hair disorders. *American Journal of Chemistry and Pharmacy*, 5(2), 1-22. <https://doi.org/10.54536/ajcp.v5i2.7925>
- Alanazi, S. M., Almohanna, H. M., & Alzouman, M. A. (2025). Lichen planopilaris associated with hair extensions in a patient with alopecia areata: A case report. *JAAD Case Reports*, 65, 147-149. <https://doi.org/10.1016/j.jdcrr.2025.07.036>
- Burla, M. J., Brody, A. M., Welch, R. D., & Favot, M. J. (2015). Anaphylactic reaction after ongoing exposure to hair glue: A novel case report. *The Journal of Emergency Medicine*, 48(1), e5-e7. <https://doi.org/10.1016/j.jemermed.2014.09.036>
- Bustard, H. K., & Smith, R. W. (1991). Investigation into the scattering of light by human hair. *Applied Optics*, 30(24), 3485-3491. <https://doi.org/10.1364/AO.30.003485>
- Cowan, Y. (2026). *Research Toolkit Biomechanical Tolerance Dataset and Computational Model for Safe Hair Extension Architecture* (Version 1.0) [Data set]. Zenodo. <https://doi.org/10.5281/zenodo.21037485>
- Imai, T. (2011). The influence of hair bleach on the ultrastructure of human hair with special reference to hair damage. *Okajimas Folia Anatomica Japonica*, 88(1), 1-9. <https://doi.org/10.2535/ofaj.88.1>
- Itegeboje, J. (2025). An in-depth analysis of sustainable sourcing practices and their environmental impact in the cosmetics industry: A case study of L'Oréal USA and Unilever USA. *American Journal of Social Development and Entrepreneurship*, 4(1), 68-84. <https://doi.org/10.54536/ajsde.v4i1.3573>
- Kajiura, Y., Watanabe, S., Itou, T., Nakamura, K., Iida, A., Inoue, K., Yagi, N., Shinohara, Y., & Amemiya, Y. (2006). Structural analysis of human hair single fibres by scanning microbeam SAXS. *Journal of Structural Biology*, 155(3), 438-444. <https://doi.org/10.1016/j.jsb.2006.04.008>
- Kapoor, R., Wang, J., Zavala, A. M., Truong, A. T., & Truong, D.-T. (2022). Metallic microbeads for hair extensions: Hidden dangers for magnetic resonance imaging. *Radiology Case Reports*, 17(9), 3274-3276. <https://doi.org/10.1016/j.radcr.2022.06.036>
- Konno, S., Asanuma, K., & Nonomura, Y. (2024). Friction dynamics of straight, curly, and wavy hair. *Journal of Oleo Science*, 73(5), 801-811. <https://doi.org/10.5650/jos.ess23245>
- Lee, Y., Kim, Y.-D., Hyun, H.-J., Pi, L.-Q., Jin, X., & Lee, W.-S. (2011). Hair shaft damage from heat and drying time of hair dryer. *Annals of Dermatology*, 23(4), 455-462. <https://doi.org/10.5021/ad.2011.23.4.455>
- Lindelof, B., Forslind, B., Hedblad, M.-A., & Kaveus, U. (1988). Human hair form: Morphology revealed by light and scanning electron microscopy and computer aided three-dimensional reconstruction. *Archives of Dermatology*, 124(9), 1359-1363. <https://doi.org/10.1001/archderm.1988.01670090015003>
- Lopez, E., Catarino, A., Poblet, E., & Jimenez, F. (2022). Alopecia due to hair extensions successfully treated with hair transplantation. *Journal of Cosmetic Dermatology*, 21(12), 6695-6697. <https://doi.org/10.1111/jocd.15380>
- McMullen, R. L., & Jachowicz, J. (2003). Optical properties of hair: Effect of treatments on luster as quantified by image analysis. *Journal of Cosmetic Science*, 54(4), 335-351.
- McMullen, R. L., & Zhang, G. (2020). Investigation of the internal structure of human hair with atomic force microscopy. *Journal of Cosmetic Science*, 71(3), 117-131.
- Nagase, S., Kajiura, Y., Mamada, A., Abe, H., Shinohara, Y., & Amemiya, Y. (2009). Changes in structure and geometric properties of human hair by aging. *Journal of Cosmetic Science*, 60(6), 637-648.
- Park, K. H., Kim, H. J., Oh, B., Lee, E., & Ha, J. (2018). Assessment of hair surface roughness using quantitative image analysis. *Skin Research and Technology*, 24(1), 80-84. <https://doi.org/10.1111/srt.12393>
- Scanavez, C., Zoega, M., Barbosa, A., & Joekes, I. (2000). Measurement of hair luster by diffuse reflectance spectrophotometry. *Journal of Cosmetic Science*, 51(5), 289-302.
- Stamm, R. F., Garcia, M. L., & Fuchs, J. J. (1977). The optical properties of human hair. I. The luster of hair fibers. *Journal of the Society of Cosmetic Chemists*, 28, 601-609.
- Sydorchuk, O., & Yi, K.-H. (2026). Hair extensions: Anatomic, biological, and clinical implications in alopecia. *Journal of Craniofacial Surgery Open*, 4(1), e0051. <https://doi.org/10.1097/SC9.0000000000000051>
- Tang, W., Zhang, S., Zhang, J., Chen, S., Zhu, H., & Ge, S. (2016). Ageing effects on the diameter, nanomechanical properties and tactile perception of human hair. *International Journal of Cosmetic Science*, 38(2), 155-163. <https://doi.org/10.1111/ics.12269>
- Thibaut, S., Barbarat, P., Leroy, F., & Bernard, B. A. (2007). Human hair keratin network and curvature. *International Journal of Dermatology*, 46(Suppl. 1), 7-10. <https://doi.org/10.1111/j.1365-4632.2007.03454.x>
- Thibaut, S., Gaillard, O., Bouhanna, P., Cannell, D. W., & Bernard, B. A. (2005). Human hair shape is programmed from the bulb. *British Journal of Dermatology*, 152(4), 632-638. <https://doi.org/10.1111/j.1365-2133.2005.06521.x>