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Single-stage nasal reconstruction with the islanded forehead flap

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KEYWORDS
Nasal reconstruction;
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Summary *Background and purposes:* Multi-staged forehead flaps are a well-recognised reconstructive workhorse for subtotal and total nasal defects. It carries the disadvantage of repeated trips to theatre for revisional surgery, which is not suited to all patient cohorts. The single-stage islanded forehead flap eliminates this need. We detail our indications and outcomes of using this flap to highlight the maintained versatility of the technique without significant compromise on reconstructive and patient outcome.
Subjects studied and methods: A prospective surgical database was collated where patients were categorised as partial or total reconstruction. We detail surgical technique and review of rationale of patient selection. Patient demographics, perioperative data and follow-up course were recorded.
Main findings: A total of 22 patients were recorded from both the U.K. and Ethiopia via working with the charity Facing Africa. Defects occurred from a mixture of trauma, Noma and cancer resections. Thirteen were total nasal reconstructions and nine partial. The mean follow-up period was 2.25 years. We experienced two major complications which required minor revision in the theatre and two minor complications, all resolved satisfactorily.
Conclusions: We demonstrate good outcomes and safety of the procedure in this first report of a varied cohort of nasal reconstructions in a heterogenous cohort of patients. We advocate the use of this flap in the multi-morbid patient where recovery can be expedited or those who have limitations from economical restraints.

Introduction

Paramedian and central forehead flaps are a well-established workhorse for a variety of nasal defects. Despite significant advances in prosthetic mid-face rehabilitation, patients prefer autologous reconstruction in our experience and those of others, and prostheses do have a recognised failure profile over time[1,2]. In ideal circumstances, patients undergo a number of staged reconstructions to obtain

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excellent functional and aesthetic outcomes. In both the senior authors' experiences, this typically includes at least three stages of surgery. However, to preserve the option of autologous nasal reconstruction for all patient cohorts, we are increasingly offering patients single-stage reconstruction. The single-stage, islanded forehead flap (SIF flap) was first described by Wood-Smith and Converse in 1963, and its advantages were described further by Park[3]. We detail our indications and outcomes in a cohort of single-stage nasal repairs using forehead flap reconstructions, to highlight the maintained versatility of the technique without significant compromise on reconstructive and patient outcome.

The senior authors are core members of head neck and facial malignancy multi-disciplinary teams, taking tertiary referrals for nasal reconstruction. In addition, they provide multi-disciplinary surgical support for a charity focussed on providing functional reconstruction for defects caused by Noma, hyena bite trauma and other disfiguring and morbid facial disease. Increasingly, within both of these disparate cohorts of patients, the desire for single-stage, safe and reproducible surgery is evident. Certain patients cannot manage or commit to a multi-stage procedure, yet, would derive significant functional and psycho-social benefit from having a nasal reconstruction[2].

We aim to describe our experience of using a single-stage technique for total nasal reconstruction, our technique, and highlight the advantages of this procedure for a sub-set of patients.

Patients and Methods

We have maintained a prospective database for all patients undergoing single-stage forehead flaps under our care. Defects were broadly classified as total or partial. A partial defect comprised a heterogenous group of defects, typically greater than a hemi-nasal defect, which were composite and required varying combinations of skin and frameworks. Total nasal defects may have included additional mid-facial reconstruction such as nasal-cheek junction reconstruction. These patients represent a heterogenous group overall. Patient demographics, perioperative data and follow-up course were recorded (Table 1).

Surgical Technique

The nasal defect is accurately templated using residual nasal tissue/nasal dimensions prior to cancer resection (if not markedly distorted by tumour bulk) or using measurements derived from well-established techniques of Menick[4]. An 8Hz Doppler probe (Figure 1) is used to map the arterial anatomy of the forehead to ascertain which flap will provide the correct arc of rotation and ease of inset for the reconstructive needs. The patient is also placed in a head-down position to ascertain subcutaneous venous anatomy, to try to include vessels within flap design (Figure 1). No quantitative method is used for flow, and the presence of a venous Doppler adjacent to the artery is deemed favourable in the senior authors experience (DBS/LRF). Where possible, it is our preference to use the supratrochlear vessels because of reliability and length. Where general anaesthesia is used,

Figure 1 Doppler ultrasound mapping of a suitable forehead flap for optimum surgical planning including venous anatomy

a caudally facing oral tube is preferred with throat packing and body warming. Local anaesthesia is only infiltrated after all flaps and recipient sites on the mid-face have been accurately marked. Only regional facial nerve blocks are preferred to reduce the possibility of nasal tissue distortion.

The flap is raised in the sub-cutaneous plane for the distal 2 cm of the flap, and then converted to sub-muscular up to the proximal one-third of the arterial origin, where the plane converts to sub-periosteal. The dissection is then carried down around the supra-orbital ridge into the infra-brow and lateral front-nasal root. In the medial brow region, dissecting scissors are used to tease away the muscular fibres around the incised flap edge, and to identify the numerous veins and small arteries still attached to the base of the flap. Where there is any concern that the arterial anatomy arises lateral to the incised flap, we apply a microvascular clamp and a check Doppler signal is within the substance of the flap. Vessels can then be safely divided. The perivascular fat at the base of the flap is left around the Doppler signal to contribute to the vascular support once islanded. In many cases, we do not actively aim to visualise the pedicle preferring to remain 'agnostic'. The senior authors feel this avoids any injury, and retains the perivascular anatomy supporting the vascular architecture and lymph drainage without restricting flap rotation.

If healthy skin exists on the cranial 1/3 of the nasal dorsum/glabella, the skin is lifted at the sub-dermal level to allow tunnelling of the forehead flap with a de-epithelialised portion of the proximal flap. We do not skeletonise the pedicle for tunnelling as we believe this would unnecessarily injure lymphatics and threaten the viability of the flap. Prior to de-epithelialisation a 'test' tunnelling is performed and if the tunnel is tight in any way, the skin of the proximal flap is not de-epithelialised and is interposed into the brow (Figure 2). Either method ensures that the fronto-nasal region is not overtly bulky. A variety of refining sutures for alar definition, dorsal strut security and trans-septal definition can be added dependent on individual needs. Doppler signal is also tested on 'mock' full transfer of the flap, and if it is lost or qualitatively inferior to that when interpolated, the flap would not be tunnelled under the glabellar skin. In

Table 1 Patient details for our cohort of 22 patients

AGE/Gender	Indication	Defect	Co-morbidity/Reasoning	Complications	Follow-up
54 F	Mucinous tumour dorsum nose	Cranial 2/3 dorso-lateral skin only	Adjuvant Radiotherapy planned	Venous congestion	2.8 years
64 F	Morphoeic BCC	Sub-total skin complete tip and lateral construct with bilateral cheek advancement flaps and conchal grafts	Thrombo-embolic disease – anticoagulated	Nil	2.2 years
91 F	Cutaneous SCC	Dorso-lateral nasal skin only	Thrombo-embolic disease – anti-platelet therapy	Nil	3 years
73 M	Cutaneous SCC	Dorso-lateral nasal skin and partial right nasal bone	Immunosuppressed solid organ recipient, Atrial fibrillation – anticoagulation therapy	Nil	2.8 years
93 F	Lentigo Maligna Melanoma	Sub-total dorsal-nasal skin and partial tip/medial crura + septal graft	Atrial fibrillation, poor mobility requested single-stage procedure	Nil	0.25 years
51 M	Trauma	Total nasal reconstruction and rib graft	Economic reasons requested single-stage surgery	Nil	2 years
25 M	Flame Burn	Total nasal reconstruction + rib graft	Economic reasons requested single-stage surgery	Nil	2 years
48 M	Leprosy	Total nasal reconstruction + rib graft	Economic reasons requested single-stage surgery	Nil	1 year
17 M	Hyena Bite trauma	Total nasal reconstruction + re-establish nasal airways with lip advancement flaps + rib graft	Economic reasons requested single-stage surgery	Nil	0.25 years
40 F	Quiescent cutaneous leishmaniasis	Total nasal reconstruction + rib graft	Economic reasons requested single-stage surgery	Nil	0.25 years
17 M	Noma Cancrum Oris	Total nasal reconstruction + rib graft		Tip cartilage extrusion – Trimmed and healed	5 years
20 F	Noma Cancrum Oris	Total nasal reconstruction + rib graft		Donor site STSG loss – re grafted 3/52 – healed	3 years
55 M	Cutaneous leishmaniasis	Total nasal reconstruction + rib graft		Nil	3 years
21 F	Noma Cancrum Oris	Total nasal reconstruction + unilateral cheek advancement + rib graft		Nil	3 years
72 F	Naso-ethmoidal SCC	Mid vault skin and osseo-cartilaginous resection + conchal grafts	Adjuvant radiotherapy	Nil	3 years – (local recurrence)
73 F	Cutaneous SCC	Partial dorsal skin reconstruction	Type 2 Diabetes, atrial fibrillation – anti-platelets	Nil	3.2 years
23 F	Chemical burn	Partial dorso-lateral skin and tip/medial crura + conchal grafts		Nil	2 years

(*continued on next page*)

Table 1 (*continued*)

AGE/Gender	Indication	Defect	Co-morbidity/Reasoning	Complications	Follow-up
M 18	Noma Cancrum Oris	Total nasal reconstruction + rib graft		Nil	3 years
F 36	Noma Cancrum Oris	Total nasal reconstruction + rib graft		Nil	3.5 years
49 F	Trauma	Total nasal reconstruction + rib graft		Nil	1.5 years
82 M	Cutaneous SCC	Total skin resurfacing and bilateral nasal bone resection	Atrial fibrillation anti-coagulated. Heavy smoker. Planned adjuvant radiotherapy	Nil	2.8 years
81 F	BCC	Right eye and nose hemi-nasal resection to pyriform margin. Partial skin reconstruction.	Requested single-stage, cannot see without glasses.	Nil	0.1 years

Key: F – female, M – male.

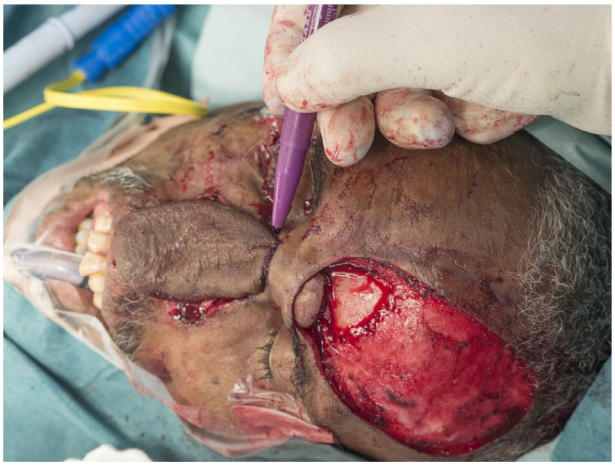

Figure 2 Trial tunnelling of the flap through a sub-dermal bridge at the glabellar region.

these instances, the glabellar tissue in incised and a small skin bridge inset.

Where possible, simultaneous harvest of autologous cartilage graft is performed. We use costal cartilage for subtotal and total nasal constructs and conchal/septal graft, where feasible, for tip or limited lateral and composite nasal structural defects. All costal cartilage rib harvest is closed with indwelling local anaesthetic catheters for early post-operative pain relief to allow early mobilisation and adherence to pulmonary physiotherapy.

The senior authors' preferences are to use drill holes in the anterior nasal spine (ANS) and a drilled 'trough' to secure columellar strut grafts. Similarly, a Fischer burr or 1-3 mm coarse diamond burr is used to create a 'slot' between the nasal bones (or their remnants) at the front-nasal angle region (Figure 3). Drill holes transversely then provide a means of securing graft by a tongue in groove method, supported by Polydioxone sutures (Ethicon, New Jersey, USA). We also favour a 'boomerang' dorsal graft to support the alar rim reconstructions and tip in subtotal and total reconstructions (Figure 4). This allows easier and accurate closure

Figure 3 Nasal defect prepared for the cartilage construct. Fischer burr used to drill the central bone away and drill holes to tongue-in-groove the cartilage dorsal strut. The upper lateral cartilages are preserved here.

of the distal folded flap around the construct, and the graft is robust enough to splint the external airway open. These grafts once inset are placed lateral to the pyriform aperture mitigate against collapse. In cases where a columellar and partial tip reconstruction are required, we use a bi-folded conchal graft (Figure 4), which offers excellent stability and flaring at the tip for additional tip and medial alar support.

Figure 4 Cartilage constructs; LEFT: Partial incision in a full conchal graft to allow folding, being ideal for tip and columella support. Alar extensions can be sutured to the robust 'flared' neo-dome the conchal graft creates. RIGHT: A complete construct with boomerang grafts (to allow downward warping where conducive) positioned securely in situ with tongue-in-groove placement at both the ANS and between the nasal bones intended.

Patients were counselled regarding graft closure of the donor site versus leaving the defect to heal by secondary intention for a less conspicuous result. Patients who were unable to attend for dressing care or who wanted to expedite healing were encouraged to undergo graft closure.

Results

A total of 22 nasal reconstructions were performed. Thirteen were total nasal reconstructions with osseocartilaginous frameworks and nine partial. Mean age was 46.5 years. Follow-up was calculated from the last outpatient assessment. The mean follow-up period for this cohort was 2.25 years.

Complications were split into minor and major, the latter being defined as a return to the theatre for an unplanned procedure. We experienced two major complications of partial tip graft extrusion and failed split skin graft to the forehead flap donor. The former was treated with trimming of the cartilage and dressings, allowing the pressure injury to heal. The failed skin graft site was re-grafted 3 weeks later and healed without further complications. We do not routinely graft donor sites unless patients prefer to avoid dressing therapy.

We observed two minor complications of venous congestion in the skin re-surfacing case, which required close early follow-up but did not result in delayed healing or dehiscence. A further case experienced prolonged flap swelling lasting 8 months, which then resolved with diligent scar massage.

Discussion

Previous reports and use of islanded forehead flaps exist[5,6] and Converse[5] first championed its use for 'unfavourable' wound beds, where skin autografts would not suffice. Converse's initial observations suggested that islanding the flap caused initial problems with venous congestion[5]. We had one case of transient venous congestion that settled within ten days with no unfavourable sequelae. In the absence of objective measures on flap perfusion, drainage and interstitial fluid shift, two logical arguments arise. Islanding; loss of dermal drainage, and/or, tunnelling; mechanical obstruction, reduce venous drainage and induce greater swelling than a flap left attached to its skin pedicle in an interpolated fashion. In contrast, our consistent observations suggest that venous drainage is enhanced. Islanding the flap avoids the kinking of venous drainage, and actually enhances venous drainage through the subcutaneous veins within the flap, which are retained (Figure 1). It is our observation that initial swelling and venous bleeding is less than those in pedicled cases, and swelling subsides within 8 weeks, leaving no footprint of lymphoedema or venous congestion.

Converse's initial observations and illustrations[5] do suggest a long de-epithelialised interval between the proximal end of the flap and its pivot region, which may have encouraged the belief that this loss of dermal drainage was a relative disadvantage. However, venous drainage is primarily axial in these flaps and narrow de-epithelialised segments for tunnelling suffice. In cases where only supra-tip, tip and columellar defects exist, the tunnel would have to be long under the dorsal nasal skin, which is tight. We do not advocate the islanded flap for such defects, because the need to tunnel through a long distance on the dorsum of the nose will certainly compress the pedicle, perhaps accounting for some of Converse's observations.

More recent descriptions and series have described single-stage forehead flaps. Park reported single-stage flaps transferred for skin replacement only in a series of relatively small defects[3]. One case required debulking of the frontonasal region but otherwise no revisional procedures were required. This series of patients was also carefully selected to avoid medical co-morbidities, which, in our experience, represent a minority of cutaneous cancer cases of the nose. Our series represents the other extreme of caseload, where co-morbidity and advanced age are prevalent, and our patients are largely derived from our cancer population and experience treating facial difference with the charity 'Facing Africa'.

Cordova described 25 cases of a single-stage flap where the majority were nasal surface defects only, and 10 cases included a composite nasal defect[7]. Three of these patients had a folded flap for vestibular skin replacement or had a flap transfer in conjunction with a chondrocutaneous composite flap. Two cases experienced partial necrosis, but it is unclear whether this mandated salvage surgery[7]. This series also differs significantly from our cohort. We have not discriminated against patients with multiple co-morbid conditions. In our experience, those of advanced age have medical co-morbidity and poly-pharmacy for chronic disease control, and still have favourable outcomes for the cross-section of locoregional reconstruction of the head, neck and face. The nose is no exception.

Paradoxically, we limit our enthusiasm for this technique to those patients that have medical limitations, because a multi-stage procedure ultimately should be possible in healthier subjects. Thus, achieving treatment in a single stage is beneficial to the multi-morbid patients because overall recovery will be expedited by fewer procedures, hospital contacts and interruptions of their normal medications, such as anticoagulant and antiplatelet therapies. Furthermore, our cohort differ in that we routinely deploy

Figure 5 Total nasal reconstruction intra-operative and post-operative in a 51-year-old male.

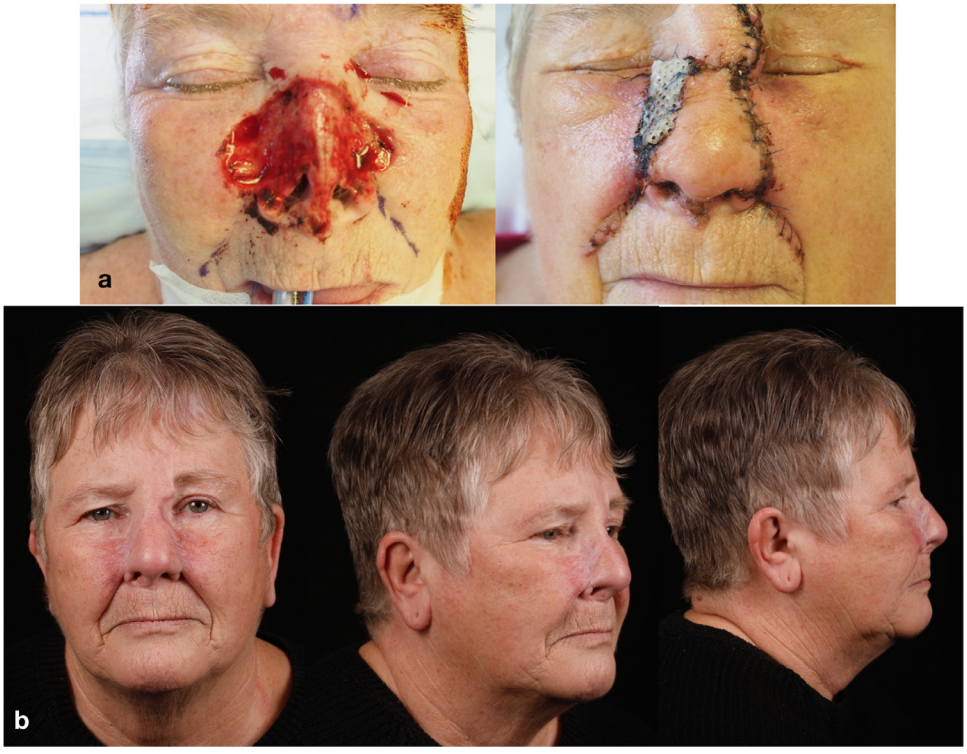

Figure 6 a: Sub-total nasal skin, partial cartilaginous and mid-facial reconstruction with bilateral cheek advancement flaps and defects 1 week post-operative in a 64-year-old female. 6b: Result at six months post-operative following minor local anaesthetic correction of the left alar base cheek flap.

the SIF and/or cartilaginous constructs, for a much more heterogenous group of defects ranging from dorsal skin replacement only, to immediate and delayed total nasal reconstruction (Figures 5-7**)**.

Our technique permits folding of the distal 1.5 cm of the flap to replace vestibular skin and caudal mucosa, providing vascular support of a cartilaginous framework. We do not feel that composite grafts are required, nor advocate their use because of unpredictability of the clinical course, and it introduces a significant chance of salvage surgery, which is our primary driver for offering single-stage reconstructions in this vulnerable population of patients[8]. Even in cases where the nasal defect is immature, we routinely medially reflect cheek skin where feasible, and advance the cheek units medially taking advantage of the excellent blood supply from facial artery perforators in this region. Whilst possible, >1-1.5 cm of distal flap folding stenoses the nasal airway. In total ablation of the nose with loss of other mid-facial structures, in our experience, a functional and aesthetically acceptable result cannot be achieved with a single-stage forehead flap. Partial, subtotal and total nasal reconstructions require at least one of the following to permit safe single-stage surgery in our experience;

1. Intact medial cheek and nasolabial skin in immature defects
2. Mature defects for reliable turn down or turn medially of residual skin[9]

Figure 7 Partial resurfacing of the dorso-lateral nose for a near 50% skin defect in a 91-year-old female 3 months post surgery. Dorsal cranial and mid-1/3 nasal skin and right lateral nose, without resection of complete sub-units is displayed. A good balance of the brow, absent swelling in the flap at an early phase and thus minimal pin-cushioning from the cicatrix are represented.

3. Non-irradiated field of surgery where turn down of skin is preferred.

We demonstrate good outcomes and safety of the procedure in this first report of a varied cohort of nasal reconstructions. Two major complications and two minor complications were observed. Meticulous planning and assessment of the forehead in this experience yield favourable subjective outcomes. We routinely offer this reconstructive method to patients where;

- Advanced patient age and co-morbidities make repeated anaesthetics or interventions undesirable.
- Perioperative morbidity may be increased (>2% risk) by modification of anti-platelet or anti-coagulant therapy (for example, in atrial fibrillation patients with a history of transient ischaemic attack in prior 12 months). Repeated stopping and re-commencing medicines could have a morbidity effect on patient physiology between planned staged reconstructions.
- The patient cannot tolerate in-patient stays/repeated visits to hospital, for example the need for regular haemodialysis, economic constraints (a driving factor in developing world patients).
- Adjuvant oncological treatment is required and multiple stages would impede treatment within the therapeutic window, particularly for skin resurfacing only cases (ideally we encourage our patients to complete radiotherapy prior to any *osseo-cartilaginous* reconstruction of the nose).
- Other oncological treatment is required at another anatomical sub-site that cannot be delayed.
- A resource-deprived environment where multiple-staged surgery is not possible for logistic or patient economic reasons.
- The patient is unwilling to have pre-expansion of the forehead where a low hair line exists.
- The patient does not favour a prosthesis.

Ultimately there are a myriad of reasons related to the specific disease, or patient circumstances that may mitigate against a multi-stage treatment plan. We believe that the versatility and safety of the SIF flap gives patients the option of a single procedure to give a robust reconstruction. Yet, should the patient feel dissatisfied with results, the morbidity of further interventions can be revisited, and we still have the options of flap refinement and further stages should these risks be adequately weighed. Thus, in surgical terms, little is lost by using a SIF flap in the first instance, as no subsequent surgical options are compromised. It does not replace a multi-stage nasal reconstruction because where possible we believe this offers the best results. We have not used PROMs in these cases but moving forward we hope to incorporate this into our practice to quantify results from the patient perspective. From the economic viewpoint, single-stage surgery avoiding complications is also desirable to the healthcare provider, albeit a secondary consideration.

Specific advantages of the SIF method include the avoidance of pre-expansion in forehead donor sites, where there is a low hairline. Expansion in our experience is generally well tolerated; however, the tissue becomes less pliant on transfer, making primary cartilage grafts challenging to accurately place and protect, and it requires close regular follow-up that can be challenging in some patient groups. Expansion is not possible in developing countries where surgical missions such as Facing Africa have a limited time window for reconstructive procedures. Islanding flaps in our experience benefit the patient by avoiding both of these eventualities. A SIF procedure also does not entirely rule out revisional surgery if requested. We are yet to have to refine a result, but we certainly will in the future. Having considered the experiences of others[7], we use photography to illustrate the fullness of the nasion in some cases, which possibly makes patients more accepting of this mild deformity, perhaps positively biasing the lack of requests for revision in our cohort.

Conclusion

We have observed stable results across a diverse cross-section of nasal defects, in a varied population of patients. High-risk patients can still receive the benefits of a nasal reconstruction in a single stage, and in an ageing population,

where bespoke oncological treatment is entering the fray, and with many medical needs, we demonstrate a safe effective way of restoring nasal form. Patient reported outcomes will further our understanding of this procedure's place in mid-facial reconstruction.

Declaration of Competing Interest

None

Funding

None

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